POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

Contents

A Question of Time 118
With the Editors 119
Utility Costs. Whence Engineering? Comfort in the Power Plant.
Rehabilitation Increases Boiler Ratings at Hampton 120
Heat Rates for Condensing Turbines. By Norris D. Gove 122
One Man Power Plants Now in Vogue. By Percival R. Moses 124
Heating and Ventilating of Central Stations. By Gustaf A. Gaffert 127
The Boiler Heat Balance and Its Calculation. By Albert T. Canfield 130
Caking Action of Coal on Stokers. By J. F. Barkley & L. R. Burdick 132
Furnace for Wood Waste 134
Coal Distribution in Stoker Hoppers 134
Lignite as Fuel in Canadian Boiler Plant. By Edward Green 135
Electrical Engineers Present Varied Program at New York Meeting 137
Electric Pressure Brazing of Cable Terminals. By Joseph A. Kendrick 140
Reducing Boiler Carryover 141
Turning Gears for Steam Turbines. By Guy Bartlett 142
Details of the Country's Largest Diesels at Vernon 143
Air Conditioning at Rockefeller Center. By Andre Merle 145
Sulzer Single Tube Steam Generator 147
Power Generation on the All-American Canal 148
A Gallon of Coal. By Geo. P. Pearce 149
Readers Conference 150
Eliminating Soot Blower Element Troubles. Rearranging Electrical Facilities. Autogenous Welding of High Pressure Boilers. A Request. Stored Rotational Energy Replaces Storage Battery. A Cause of Boiler Tube Bursting. Center Holes for Stud Bolts. Alteration Cost Prevented by Use of Fan Ventilation.
New Equipment 154
Condenser Tube Fastening. Steam Turbine Driven Fuel Oil Pump. Refrigeration Compressors. Condit Electrical Mfg. Co. Develops New Circuit Breakers. Super Centrifuge. Crankless Diesel. New Intake Air Cleaner. Steam Turbine Speed Reducer Units. New Limitorque Valve Operator. High Speed Pumps. Harnishfeger Small Lighting Plants. New Totally Enclosed Motor. Transparent Draft Gages. Redler Conveyors. Universal Coil Winder. Self-Cleaning Strainer. Gardner-Denver V Type Compressors. Small Diesel Generating Sets. Severe Service Valves with alloy trim. New Vogt Valves for high pressures.
Milwaukee and Wisconsin Industrialists Elected M.A.P.I. Executives 158
News from the Field 159
For the Engineer's Library 160
Power Plant Construction News 162

Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index on file in Public Libraries.

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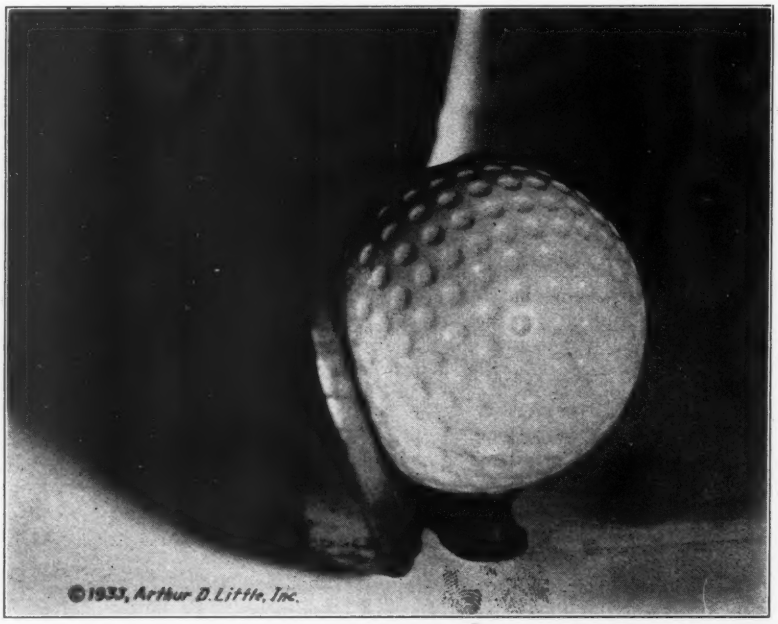
POWER PLANT ENGINEERING March 1934

A QUESTION *of* TIME



HAVE YOU EVER wondered how a poor defenseless golf ball feels when with one of your mighty talked-of strokes you knock it for a row of something or other or plant it deep in the turf a few inches away, depending upon your form? Well, maybe not, but we can assure you it is no fun for the ball. Just look at this picture. Here you see a ball just at the instant it is being knocked off its tee and the poor thing is all lop-sided, flattened out in fact. How can you expect it to travel straight when its form is so distorted? No wonder it goes in the rough.

But wait—maybe things are not as bad as they seem. Maybe this flattening is not permanent. And indeed it is not. What you see here is purely a transient condition, something that exists only for an instant and then disappears. It is purely a question of time. For this remarkable picture is one of those taken by Dr. Edgerton of the Massachusetts Institute of Technology at a speed of in the neighborhood of a millionth of a second. By means of a new method of lighting, utilizing high powered electrical discharges through an improved type of mercury arc lamp, Dr. Edgerton has been able to take motion pictures at the rate of 6000 pictures per second and still pictures with an exposure of only one millionth of a second.

So, what you see here, in the flattening of one side of the ball, is really a picture, so to speak, of the potential energy stored in the ball just before it starts on its flight through space. The re-transformation of this potential energy into kinetic drives the ball forward. Theoretically, the explanation is more involved for it really requires a consideration of the distortion of the electrical fields of electrons and atoms comprising the ball, but for our purposes here, this aspect of the action need not be considered. The thing of interest here is that though the ball is free to move, it is actually compressed on one side, showing the effect of inertia. The kinetic energy of the club an instant before is now stored in the ball as potential energy by virtue of the ball's elasticity. Analysis of pictures such as these has yielded considerable information concerning drives made by Francis Ouimet. In every drive the initial velocity of the ball was greater than that of the club.

Aside from its general interest this picture is of particular importance to us as engineers. Photography has always been an important adjunct in engineering investigation and analysis and this new high speed method of photography opens up a vast new field for the investigation of machine operation. In the search for hidden causes of imperfect operation in complicated machinery it has already been applied with remarkable success. In the power plant field it has many applications. It should be particularly useful in the analysis and correction of vibration in turbines, pumps, fans, etc., or in the study of motor or generator performance. In one instance, angular displacement studies were made of generators and motors under conditions of instantaneous disturbances such as caused by surges.

One picture may be worth a thousand theories, especially if action which is a confused blur to the human eye can be "stopped" at a critical instant or slowed down on a motion picture screen to allow careful and unhurried study. Turbulent water can be made to assume a lava-like viscosity. In the study of cavitation in hydraulic turbines and pumps the application of this method has brought out a number of new facts.

It is developments of this character that make science and engineering ever fascinating. This system of photography does for time what the microscope and telescope have done for space. It gives us a better insight into the "fourth dimension." It is a new tool for our researches.

WITH THE EDITORS

Utility Costs

AN INTERESTING SIDELIGHT on utility costs is given by an analysis of the tax and operating costs of the Detroit Edison Co. system for the year 1933. Under the capable engineering and financial leadership of Alex Dow, one of the few remaining major utility executives who speaks the language of the engineer, the company has made noteworthy progress. It has maintained a conservative financial policy and clung to the rather old fashioned idea that the primary function of a utility company is to serve the community and not to serve as a building unit for bankers' paper pyramids. The operation may therefore be considered the best that can be accomplished in a compact system with a diversified industrial, residential and rural load. Says the Synchroscope:

"Out of every dollar we took in during 1933 we paid 12.7 cents for taxes alone. Comparing our tax bill with some of our other bills: For every dollar we paid for coal, we paid $1.44 in taxes; for every dollar we paid to stockholders, we paid $1.05 in taxes; for every dollar we paid in wages, we paid 52 cents in taxes; for every dollar we appropriated to retirement reserve, we paid $1.31 in taxes. The Michigan Sales Tax of 3 per cent, which is imposed on most of our local purchases, is not included as a tax in the above comparisons, but as additional to the 12.7 cents."

These five items: wages, 24.4; taxes, 12.7; dividends, 12.1; reserve, 9.7 and coal, 8.8, account for about 67.7 per cent of the total income of the company, which in 1933 was $41,492,268.62. The total production of power was 1,908,671,700 kw-hr. with a peak load 409,200 kw. reached between 6 and 6:30 p.m. on December 28.

Assuming for the moment that these earnings are entirely from the sale of power the unit revenue amounts to about 21.65 mils per kw-hr., divided as follows: wages, 5.3 m.; taxes, 2.8. m.; dividends, 2.6 m,; reserve, 2.1 m.; coal, 1.9 m. The rapidly mounting importance of taxes is apparent, overshadowing as they do the cost of coal by approximately 50 per cent.

Whence Engineering?

JUST HOW MUCH credit modern man deserves for his accomplishments in the world is questionable. In fact, credit must be liberally mixed with condemnation for modern man was inexcusably dumb in development after primitive man gave him a generous start.

Before the time of Christ, the wheel, the windmill, the water wheel, the pump, the expansive force of steam, the steam turbine, the gear, the lever and the art of working metal was known either in fact or in principle. Even the principle of printing, which deserves so much credit for the rapid spread of knowledge during the last few centuries, is lost in antiquity for the reverse cut seal can be classed as nothing else.

But even with this start which includes all the principles of our modern civilization, man took almost 2000 yr. to put them into action, leaving some question as to whether primitive or civilized man is the more intelligent. Even the principle of the Diesel engine was known and utilized by at least one of the supposedly savage tribes, the Dyaks of the South Sea Islands.

These people used the temperatures of highly compressed air for fire making. The device consisted of a cylinder with a bore of about ⅜ in., 3½ in. long and closed at one end. In the end was fitted a piston packed with soft packing and with a recess for tinder. The piston, driven home by striking the piston rod a sharp blow, compressed the air sufficiently to ignite the tinder.

Perhaps the old saying, "There is nothing new under the sun," is not literally true but it has a basis of fact. No evidence has yet been uncovered showing that ancient man played with electronic tubes or tried to weigh the sun and planets but in spite of this his intelligence and ability as an engineer must rank with that of modern man.

Comfort in the Power Plant

AT EVERY TURN you make while going through a power plant you encounter a different atmospheric condition—hot, cold; dry, moist; clean, dust laden; still, drafty; sweet and pure or contaminated with injurious gases. As a rule the power plant worker is not placed in what may be classed as unhealthful surroundings, for time lost on account of sickness of employes is not great as compared with other occupations.

Such conditions as prevail are no longer necessary nor desirable, neither from the standpoint of economy nor the welfare of the workmen. The usual adverse argument is that the waste heat from boilers, piping and steam using equipment will be sufficient to heat the entire building and that the boiler will do all the necessary ventilating. In cases where waste heat is depended upon to provide comfortable temperature for workmen, neither heat nor ventilation are under control, the temperature is not uniform throughout the building, it is too hot in summer and too cold in winter and, with windows as the only means of regulating temperature, an enormous amount of useful heat may be wasted. An insufficiently insulated or poorly designed plant will heat parts of the building sufficiently even in winter but at a cost in efficiency far in excess of a well designed heating system.

As in efficiency of operation, central station utility plants have led the field in the practice of providing comfort for their employes and the general outlines of the systems employed, as given by Mr. Gaffert in this issue, should be an aid to engineers in making plant improvements, for the human element should not be overlooked in carrying out any extensive modernization program.

POWER PLANT ENGINEERING March 1934

Rehabilitation *Increases* Boiler Ratings *at* Hampton

FIG. 1. FIRING AISLE SHOWING SOUND PROOF PULVERIZER HOUSINGS

Remodeling at boiler room at the Hampton Station at the Virginia Public Service Co. increased boiler ratings from 250 to 400 percent. Three of the existing boilers were reset and equipped for pulverized coal firing with air cooled furnaces

FROM AN ENGINEERING point of view, the rehabilitation or the remodeling of an old plant is usually of greater interest than the construction of an entirely new plant. Not only is greater ingenuity necessary in adapting existing equipment to new conditions but greater resourcefulness is required on the part of those doing the work in keeping the plant in service while the changes are being made. An interesting instance of the rehabilitation of a small central station plant came to our attention some time ago—that of the Hampton Plant of the Virginia Public Service Co.

This plant had 19,500 kw. of turbine capacity in five units with a total of 4210 b.hp. of 200 lb., 125 deg. F. sup. stoker fired boilers in seven units. All except two of the stokers were short depth and the boiler room capacity did not match the turbines. In order to increase the plant capacity and to gain incidental advantages in economy, three 640-hp. boilers were changed to pulverized fuel.

The width of the boiler room was only 45 ft. 2 in., making it extremely difficult to work the installation into the existing building. However, the design adopted made it unnecessary to change the building roof or walls. Fortunately, at the end of the row of boilers there had been kept a space for a future battery of boilers and this space was utilized in making the change in boiler settings.

The problems presented in the redesign of this plant were as follows:

1—The plant needed more capacity of a reliable character. There were sufficient boilers installed, but the capacity developed from these boilers was not sufficient to take care of the gradually increasing load of the station.

2—The plant needed higher boiler room efficiencies and elimination of cinder nuisance which was causing some complaint in the residential district.

To accomplish these things with the least expenditure of capital and with a capital expenditure that would be justified by the savings involved was largely the problem presented from an engineering viewpoint.

For economy reasons, it was decided to reset three of the existing boilers, with space allowed for the fourth at a later date, for pulverized fuel firing. The boilers were taken out, turned around and set with a dry bottom, air cooled refractory, pulverized fuel installation. The furnace liberation was kept to a maximum of 16,000 B.t.u. per cu. ft. A horizontal single burner was installed taking secondary air from the room.

Air Preheated to 300 Deg. F.

To cool the air-cooled refractory walls, the primary air is passed through these walls in an upward direction, distributed evenly over the whole area and also across the bottom of the furnace, every second upward air lane in the side walls taking air in opposite directions across the floor prior to entering the wall. This gives air temperatures of about 300 deg. F. entering the pulverizer which is sufficient to take care of the moisture content of the coal.

With this arrangement, the secondary air is entirely induced into the furnace through the secondary air openings of the burner by the action of the induced draft fan which maintains the furnace pressure at about 0.1 to 0.5 in. less than atmosphere, whereas the primary air after passing through the mill is used as conveying air for the coal and enters the furnace under the action of the single primary fan. The furnace

working below atmosphere results in any air infiltration or leakage being from the air duct inward and therefore removes the hazard which might occur from leakage outward if the furnace were working at a balanced pressure or even slightly above atmosphere, that is, the air leakage inward prevents any flame outward damaging the supporting structure for the air cooled walls. The walls on the interior glaze over with a thick layer of molten ash and make a very tight furnace so that the air infiltration is reduced to a minimum.

The pulverizers chosen were Foster Wheeler Hardinge mills and were developed with a worm gear drive with a vertical motor. This arrangement is lubricated with an oil circulating system from the gear driven oil pump taking oil from the oil storage in the base of the pulverizer, the oil pump not only lubricating the gear but also the bearings in a manner a good deal similar to a turbine oil lubricating system. The vertical drive has the advantage of compactness and a minimum air space which, in the Hampton plant, was a necessity on account of the very limited space which was available for installing the mills.

Sound-Proof Housings for Pulverizers

The entire pulverizer is covered with a stationary sound-proof jacket and the operation of the combined pulverizer driven by the worm gears and enclosed in the sound-proof jacket is noticeably quiet.

The pulverizer is fitted with the Foster Wheeler level control as an indicating instrument and the boilers are equipped with Bailey meters apportioning the air and fuel and with the usual draft gauges, thermometers, etc. The open type burner permits of easy vision of the flame distribution across the furnace and shows readily the distribution of coal in the burner. Each boiler is equipped with a single induced draft fan and an extended surface economizer, the water entering the economizer at 212 deg. F. or thereabouts and the gas leaving the economizer at full rating at about 350 deg. F.

This makes a very simple and easy operating installation because there are no air heaters and no forced draft fans, the only fans operating being the induced draft fan and the primary fan which is part of the pulverizers.

Dust Removed by Electrostatic Precipitators

After leaving the induced draft fan, the gas passes through a duct system to a Cottrell electric precipitating system where a very large percentage of the suspended ash in the gas is removed and the clean gases go to the existing natural draft stacks and are emitted to the atmosphere in the usual way. The control of the combustion, combined with the action of the Cottrell Precipitator is such that the emission from the stacks is an almost colorless, very light haze and this arrangement has entirely eliminated any complaints from ash deposits due to this station.

The removal of the precipitated ashes presented a problem which had to be solved. A special mixing conveyor was constructed, a good deal on the principle of the continuous mortar or concrete mixer. The ash is taken from the hoppers of the Cottrell Precipitator, runs through this continuous conveyor, which is of a closed type, and is mixed with water during this process, from which it is passed to open cars in a wet, mixed mass, this work being done in an enclosed building which takes the car therein. The result is that when the cars are hauled away, the ash is in a wet condition where it will not be moved by wind or other disturbing elements. It is conveyed in this condition to the point of disposal without nuisance to the neighborhood.

Considerble work had to be done on the special conveyors for wetting and conveying this ash to the car in order to get a reasonably satisfactory action in the wetting of the ash. As is well known, fly ash in general tends to float on water and does not wet easily. It was with some difficulty that a conveyor mixing device was developed to a point where it would produce a uniformly wet mixture without occasional slugs of dry material coming through. This has been in general accomplished in a satisfactory manner and seems to be one solution of an otherwise difficult problem.

The ashes which settle in the bottom of the furnace are removed periodically by hand to a hydraulic sluicing system, where they are taken out and loaded into cars.

It is possible to get 400 per cent of rating from these boilers for short periods of time, as compared with 250 per cent on the short stoker and 275 per cent on the long stokers. The boiler drums limit the rating that can now be carried.

In concluding this article we wish to extend credit to M. J. Idail, manager of engineering of the Virginia Public Service Co., and to R. C. Roe, consulting engineer of New York City, for data used as the basis of this article. For photographs we are indebted to the Foster Wheeler Corp.

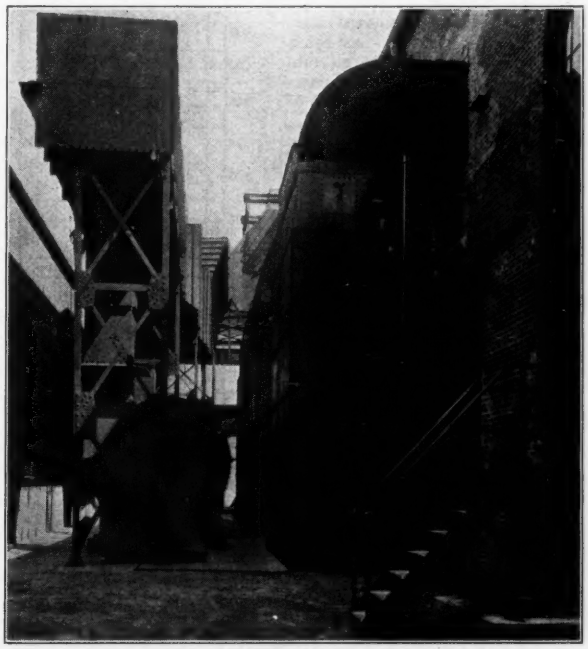


FIG. 2. ECONOMIZERS INSTALLED OUTSIDE OF BUILDING DUE TO SPACE LIMITATIONS

The fan at the left discharges flue gases from the first economizer into the duct at the top of the picture. The duct conveys the flue gases to the electrostatic precipitator.

POWER PLANT ENGINEERING March 1934

Heat Rates *for* Condensing Turbines

Heat Rate Which Can Be Converted Directly Into Coal Figures Is Used as Basis of Charts Which Allow Rapid Comparison of Performance to Be Expected Under Various Operating Conditions. By Norris D. Gove*

IN THE COURSE of a designer's daily work of preparing quoting information on new turbine applications and later on of designing the turbine sold, there are frequent inquiries of a comparative nature. That is, prospective customers ask for simultaneous quotations on turbines for 150, 250 and 400 lb. pressure, or for different superheats or for varying vacuums. Occasionally as many as a dozen propositions are requested and in one long remembered instance, 108 complete sets of performance were requested and obtained. This covered three ratings, four initial steam pressures, three superheats for each pressure and three vacuums, think of the labor involved—and the profanity.

In the last analysis, however, a reasonable degree of this sort of thing is really necessary. Few purchasers of turbine equipment, particularly of the industrial sizes, have the accumulated data and experience available to select practically off hand the most advantageous operating range. Nearly everybody knows that 400 lb. throttle pressure yields a better water rate than 150 lb., that superheat is helpful and that 29 in. vacuum is better than 27 in. But this is not enough. High pressure plants cost more than low pressure ones and probably require more skilled operators. The condenser price for a given turbine varies largely in proportion to the vacuum it will produce. With cheap coal or waste fuel thermal efficiency becomes a small factor and plant costs increasingly important. In short, a commercial balance must be struck between a multitude of diverse components so that the power plant output may be obtained at the lowest cost.

*Design Engineer, Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

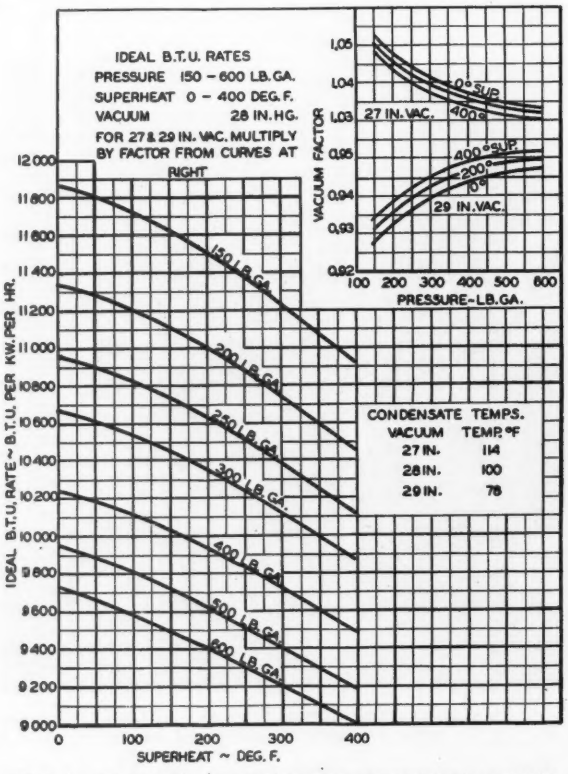


FIG. 1. IDEAL HEAT RATES FOR DIFFERENT STEAM AND VACUUM CONDITIONS

Curves Give the Required Data Quickly

From the foregoing, it is evident that the turbine buyer, represented by the consulting engineer or the plant manager, must obtain from the turbine manufacturers as well as from many others a large amount of exact and detailed information before he can ask for a final quotation. The gathering of the information by the present method of asking the turbine manufacturer to work up a series of propositions consumes much time and imposes a considerable expense on the manufacturer. Suitable information in the possession of the buyers would, if used, greatly reduce the time and money spent in the preparation for buying a turbine. Such information must be reasonably accurate at any individual point and must also be highly comparative so that trends may be studied and comparisons made without running into the difficulty of having permissible close approximations transformed into large cumulative errors. The curves for straight condensing turbines presented herein were made up with these rather exacting requirements in mind.

In the industrial sizes, turbine performance is usually obtained on the basis of water rates. With varied steam conditions these do not give a true, direct comparison on account of the different amounts of heat which must be supplied per pound of steam. The best criterion is the B.t.u. rate which may be defined as the heat used per kilowatt generated. As applied to straight condensing turbo-generators, it may be readily obtained from water rates, with the help of steam charts, by the formula.

$$\text{B.t.u. rate} = (i_1 - i_2) \times \text{W. R.} \qquad (1)$$

where i_1 is the heat per lb. of steam supplied, i_2 is the heat returned per lb. of condensate, W.R. is the turbine water rate in lb. per kw-hr.

The term has become familiar to the central station industry where because of feed heating the equation takes the form

B.t.u. rate =

$$\frac{\text{Total heat supplied—total heat returned}}{\text{Total kw. generated}} \qquad (2)$$

The performance of entire plants is often given in the form of B.t.u. rate in which case

$$\text{Plant B.t.u. rate} = \frac{\text{Total B.t.u. in coal used}}{\text{Total kw. output}} \qquad (3)$$

The turbine B.t.u. rate can be transposed readily into coal rate by multiplying it by a small factor to take care of auxiliary steam demands and dividing the result by the product of combined boiler and furnace efficiency multiplied by the B.t.u. content of the coal used.

For example: Coal rate in lb. of coal per kw-hr. equals

$$\frac{\text{Turbine B.t.u. rate} \times 1.05}{0.75 \times 13{,}000} \qquad (4)$$

where 5 per cent of the steam is required for auxiliary uses, the boiler and furnace efficiency is 75 per cent and the coal has a heat content of 13,000 B.t.u. per lb. Because it lends itself to direct comparison and because it may be transmitted readily into terms of fuel, the B.t.u. rate has been used as the basis of the curves shown herein.

Theoretical Heat Rate

The first curves, Fig. 1, are really a byproduct. They were developed as the basis of construction of the final curves and are shown here for the use of those who may be interested in the theoretical relationship. They give the B.t.u. rates which might be expected with a perfect turbo-generator, i.e., with 100 per cent efficiency. They are calculated from the latest steam charts resulting from the A.S.M.E. steam research of the past 4 yr. and show in a simple picture the comparative heat requirements of a perfect turbine.

Curves in the left hand portion of Fig. 2 show the actual B.t.u. rates of a 2000-kw. turbo-generator for various initial steam conditions and 28 in. vacuum. They are shown in the same general form as in Fig. 1 so as to facilitate the comparison of the different conditions. It can quickly be seen that 400 lb., 300 deg. F. superheat is better than 150 lb., 0 deg. F. superheat and the scale at the left gives the actual heat consumption in B.t.u. per kw. for each. The comparison holds true for other ratings but the absolute values differ since they depend on the varying characteristic, turbine efficiency.

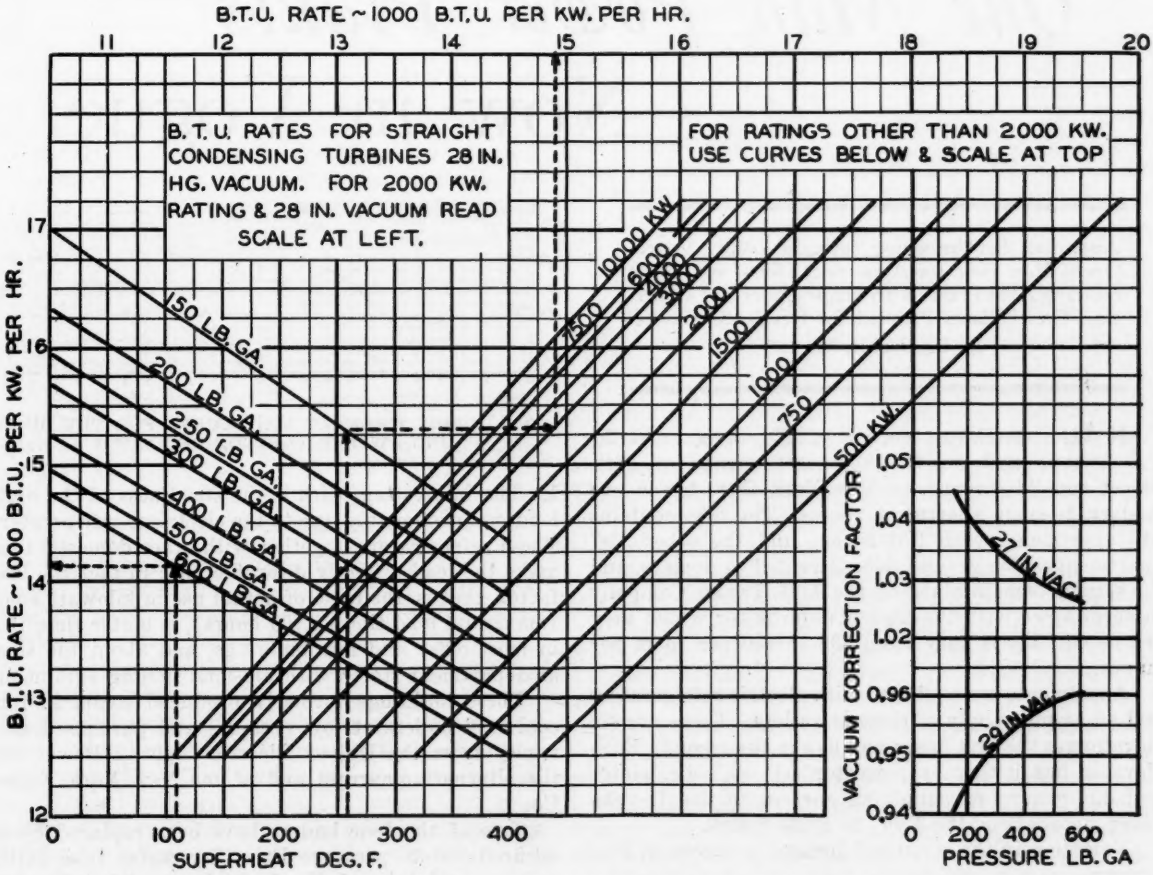


FIG. 2. ACTUAL TURBINE HEAT RATES THAT CAN BE EXPECTED FOR STRAIGHT CONDENSING TURBINES

To obtain the actual values for other ratings use the upper scale, reaching it by the method shown by the dotted lines. For instance, the B.t.u. rate for a 3000-kw. turbine operating with steam conditions of 150 lb. ga., 260 deg. F. superheat, 28 in. vacuum, would be 14,900 B.t.u. per kw. If other information at other vacuums is required, the results obtained above may be multiplied by factors obtained from the vacuum correction curve in the lower right hand corner.

These B.t.u. rates are, of course, given for the normal full load rating of the unit. Partial load rates vary considerably but as a rule rates at ¾ load will be from 1½ to 4 per cent higher and ½ load rates 7 to 14 per cent higher than at full load, the larger factors applying in general to the smaller ratings. The heat requirement at 1¼ load (100 per cent power factor) will usually be about the same as at full load. Using these values there should be no difficulty in making up a performance curve which will be reasonably close to the guarantees of the various turbine manufacturers and which will enable the buyer to compare not only different steam conditions but various ratings as well.

Information of the type presented herein should not be offered without conveying some idea of its limitations for the protection of the user. Figure 1 which is also the framework of Fig. 2 is based on the latest thermal experiments of the A.S.M.E. No change should be expected of such magnitude as to require alteration to this work when taking into consideration the scale used. In Fig. 2 the basic framework, ideal B.t.u. rates, has been modified by two major factors: First, correction for pressure, superheat and vacuum; second, turbine efficiencies. The effect of pressure and superheat does not vary much with type or design. Vacuum presents a greater potentiality for variation but most commercial designs now attain high efficiencies in the exhaust blading so that the shape or values of the vacuum curves should not change much.

From the viewpoint of comparison the curves are representative and should not change with the years. As regards the absolute values, however, the situation may be different. These are based on turbine efficiencies and may change from day to day and from year to year with three major manufacturers competing for favor. The efficiencies used were based on the 1933 level, conservatively rationalized to permit development into curves. The results cannot, of course, agree with all individual efficiencies of turbines sold in that year but do give a fair idea of what turbine builders in this country are now doing. Increases in basic turbine efficiencies will probably be made at a low rate, the level now being high, and these curves should be accurate enough for study purposes for some time.

One Man Power Plants Now in Vogue

Automatic Synchronizing with the Utility System Opens New Field for Apartment House and Office Building Field Plants with Single Boiler and Generator. Diesel Plants Planned for Residence Service.

By Percival R. Moses*

ON THE northwest corner of 22d Street and 2d Avenue and on the northeast corner of 68th Street and 2d Avenue, in New York City, tower two modern 18-story apartment houses. The first contains 346 apartments with 970 rooms, and the other, 287 apartments. The ground floor is rented to doctors, and the service is maintained by the J. H. Taylor Company in accordance with the high standards for which they are noted. Rents vary from $38 to $50 per room per month.

Apartments are equipped with electric refrigerators and an ample supply of electric outlets. There are six elevators in the first house and five in the second. Each elevator has its motor-generator set with a.c. motor and d.c. generator, supplying current to the d.c. elevator motors from the 3 ph., 60 cycle system.

Variation in the electrical demand is shown in Fig. 1. The interesting point is the steadiness of the night load, unquestionably due to the electrical refrigerators. These refrigerators, together with other domestic uses, make the load a highly desirable one; in fact the load factor, that is, the ratio of actual use in kilowatt hours (maximum load times 8,760 hours), is better than that in most office and loft buildings, and about the same as department stores with air-conditioning equipment.

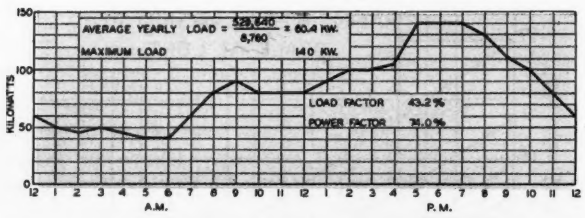

AVERAGE YEARLY LOAD = 529,440 / 8,760 = 60.4 KW.
MAXIMUM LOAD 140 KW.
LOAD FACTOR 43.2%
POWER FACTOR 71.0%
KILOWATTS
150
100
50
0
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
A.M.
P.M.

FIG. 1. DAILY WEEKDAY LOAD CURVE FOR THE BUILDING AT 315 E. 68 ST. ON DEC. 6, 1933

These buildings formerly produced steam in four coal-fired boilers at low pressure and purchased electricity from the United Electric Light & Power Co., the alternating-current end of the New York Edison Co.

Two of the four boilers have been replaced by an oil-fired 200-lb. pressure Erie City water tube boiler, and seven-eighths of the electricity used is being pro-

*Consulting Engineer, 570 Lexington Ave., New York, N. Y.

duced now by a 175 kw. (250 kv.a.) Electric Machinery Co. generator directly coupled to an Ames 3-cyl. vertical unaflow engine.

These plants are interesting because they are designed strictly as one-man plants. They are ideally simple. The boiler and the electric-generating plant are in the same room. The engineer has nothing to do except to see that the apparatus functions and to control the supply of live steam to heating system and hot water so that due economy may be obtained.

Boilers and oil-burning equipment are not automatic. Each boiler has two burners, and each plant is supplied with removable burner tips to allow the quantity of oil fired to be adjusted closely to the demand. This varies from 1,500 to 9,000 lb. of steam per hr. The engine-generator set is entirely automatic. The lubricating oil is continuously filtered and passed through a separator and cooled before being returned to the engine. These sets are guaranteed to deliver a kilowatt hour for 32 lb. of steam at full load with 175 lb. initial pressure and (one pound) the heating pressure on the exhaust.

During the heating season the demand for steam for heat and hot water is several times that required for generating electricity, so during this period the electricity is a by-product of the heating, and the extra fuel required to generate steam at 175 lb. pressure instead of at one or two pounds is about balanced by the greater efficiency of the high pressure oil-fired boiler. During extremely cold weather, the high-pressure boiler is supplemented by one of the coal-fired boilers, which is then operated to supply steam for hot water at low pressure.

The plan of operation contemplates shutting down the generating plant from midnight until 6 a. m., except in very cold weather, when steam will be kept on all night. During the shutdown period, electricity will be purchased from the United Electric Light & Power Co. under the breakdown, or as it should be called, auxiliary service rider, whereby the consumer guarantees to use $24 worth of electricity a year for each kilowatt of demand. In these two buildings the contract demand is for 125 kw.

During the non-heating season, about one-fourth of the exhaust steam from the engine will be used in the hot-water heating system and in the feedwater heater. The surplus will be exhausted to the atmosphere through an automatic back-pressure valve discharging into smoke stack.

Automatic Synchronizer

Another interesting feature of these plants is the automatic synchronizing device developed by the consulting engineers in conjunction with the Roller Smith Co., which supplied oil circuit breakers with special mechanical interlock and using a General Electric Co. synchronizing relay.

To avoid shutting off current even for a fraction of a second, it was necessary to provide for parallel operation with the utility service for such fraction of time. Without such arrangement it would have been necessary to provide other means to insure continuity of service, as failure to do so would have caused several hundred electric clocks to stop, and, as a number

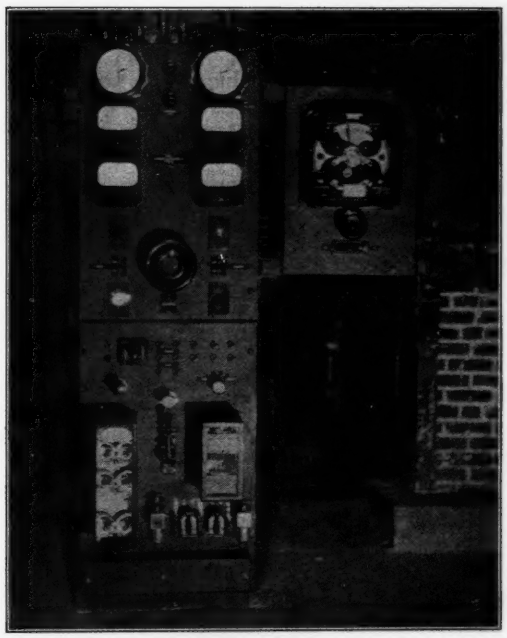


FIG. 2. THE EQUIPMENT THAT SYNCHRONIZES THE BUILDING UNIT WITH THE UTILITY SYSTEM

were the usual non-self-starting kind, the service would have been unsatisfactory.

The automatic synchronizing and cut-out device parallels the United Service at synchronism for a fraction of a second and then cuts out either the plant or the United Service. The device functions perfectly, and reference should be made to the coöperation shown, at the suggestion of Deputy Commissioner Ryan of the Public Service Commission, by Mr. Tapscott, Chief Engineer of the United Electric Light & Power Co. Front view of the control switchboard with the automatic synchronizing device is shown in Fig. 2.

Chimney Serves Double Purpose

Another interesting and novel arrangement is the plan adopted for ventilating the boiler and engine room at 68th Street. Objection was raised to the discharge of warm air into an alley at the end of the building; so a Prat-Daniel Venturi draft inducer was introduced into the smoke connection to the main chimney. A fan draws air from the boiler and engine room and discharges it through a Venturi section into the breeching. The chimney, therefore, serves not only to take off combustion gases but also hot air from the boiler and engine room.

As absence of noise and vibration was essential, the matter of isolation of foundations and connections was thoroughly studied. The Electrical Research Products Corp. was employed to measure sound and vibration, and the Bureau of Standards in Washington also advised.

The engines and generators are mounted on heavy concrete foundations, lined below and on all sides with cork installed by the Korfund Co. All electrical connections are flexibly connected to generators to avoid transmission of vibration, and all steam exhaust pipes are on Grinnell spring hangers for the same purpose.

It was also essential that lighting should be free

from flicker when elevators started and stopped. A study of the load variations was made and the contracts for the equipment included an absolute guarantee against observable flicker, and the guarantee has been fully complied with. A voltage regulator made by the Allis-Chalmers Co. is an essential part of this equipment and without it no such guarantee could have been made. This, together with a special construction of the exciter and the generator and design of the flywheel of engine has made nonflickering performance possible. The motor-generator sets used for elevator operation have also an important bearing on the successful solution of this problem.

Costs

Costs may be valuable to others planning the same type of improvement. The actual costs have been adjusted to correspond with increase due to the NRA.

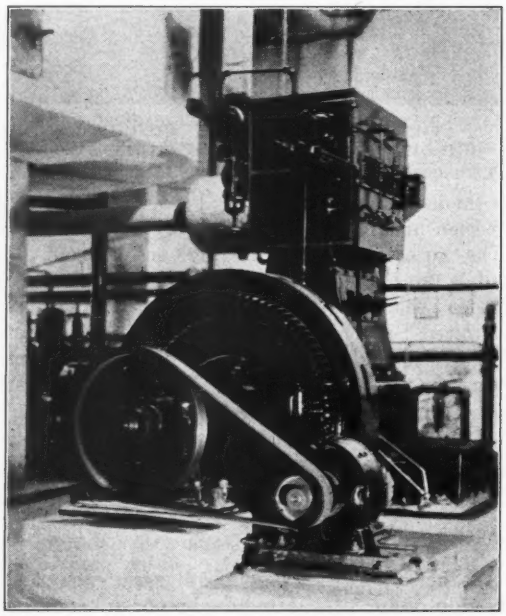


FIG. 3. ARRANGEMENT OF THE ENGINE AND BOILER

Investment required for plants similar to either 22d Street or 68th Street will be between $33,000 and $35,000. This can be made a quarter to a third in cash and balance can be paid out of savings in 2 yr. It is estimated that the former cost of around $29,000 a year covering electricity at wholesale rates and steam, will be reduced to $18,000, including $3000 for United Electric service—a gross reduction of $11,000 a year.

As there were three men, one on a shift, firing, prior to installation of new plant, no men have been added, but higher-priced men have been necessary, and the additional labor cost is about $2100 a year.

During the four winter months (December to March, inclusive), the quantity of fuel used will not differ materially from that used prior to the installation of the plant; but to facilitate operation and to obviate handling of coal and ashes, oil has been substituted for coal. During the balance of the year the additional fuel oil required is estimated at $3100. Other items such as lubricating oil, water, insurance, repairs and supplies total $1000, making the cost of operating and maintaining the electrical generating plant at $15,000, to which must be added $3000 for United Electrc Light & Power Company service—a total of $18,000.

On this basis the investment will be repaid out of reduction in cost within 3 yr., and thereafter there will be a net saving of $11,000 a year.

Diesel Plants

Plants such as these offer a real and perhaps the principal means of cutting expenses in large apartment houses. In many houses the Diesel units will work out best. Careful consideration was given to the use of these in 22d Street and 68th Street.

Over a 20-yr. period the Diesel plant might have worked out as a better investment; but with the uncertainty of the existing situation and the disinclination of owners to make long-term commitments, the single steam-driven unit with United Electric Light & Power Co. service as auxiliary seemed the best.

In another location where apartments are spread out and auxiliary service is not available because of restrictions against submetering, a three-unit Diesel electric plant is being planned. In this group the investment will be $50,000 and the profits $20,000 because the electricity will be sold to tenants at retail rates; whereas in 22d Street and 68th Street the competition is with the wholesale rate, as submetering is already functioning.

Unquestionably the isolated plant has a bright future. The Diesel, the oil-fired boiler, and the self-contained automatic unaflow have changed the picture from that which existed 10 yr. ago, and the need for economy has supplied the impetus necessary to force building owners to question ideas fostered by exceptional conditions which arose during the War and continued to 1930.

LIST OF EQUIPMENT MANUFACTURERS

Boiler	Erie City Iron Works
Reducing Valves	Kieley & Mueller, Inc.
Vertical Uniflow Engine	Ames Iron Works
Oil Separator	Stickle Steam Specialties Co.
Boiler Feed Pumps	American Steamp Pump Co.
Oil Burners	Coen Co.
Hangers	Grinnell Co.
Feedwater Heater	The Hoppes Manufacturing Co.
Foundation Insulation	Korfund Co.
Generator	Electric Machinery Mfg. Co.
250 kv-a., 120/208 v. 3-phase, 60 cycle, 400 r.p.m., with Texrope drive. Exciter: 10 kw., 125 v.	
Voltage Regulator	Allis-Chalmers Mfg. Co.
Rocking contact.	
Switchboard	Lexington Electric Products Co.
Instruments & oil circuit Breakers	Roller-Smith Co.
Relays	General Electric Co.

Preservation of efficiency with time is an important problem of turbine design. It has gradually become conventional to allow ¾ to 1 per cent as unavoidable drop in efficiency during the early years. This change is due to a variety of causes, such as coating and corrosion of the blading, enlargement of clearances due to wear of sealing strips, and disruptions in the alignment of stationary and rotating blades due to creep and cylinder distortions, and so on. The drop in efficiency generally proceeds at a slower rate as the turbine grows older.—C. R. Soderberg.

Heating and Ventilating of Central Stations

Waste Radiation Is No Longer Depended Upon to Heat the Power House but Steam and Hot Water Systems Are Employed. Ventilation Is Essential to Keep Down Temperatures and to Dry Humid Atmospheres.

By
GUSTAV A. GAFFERT

SOME new angles arise in the design of a satisfactory heating and ventilation system for a central station. There are so many different conditions to be handled that one system alone rarely suffices, and separate treatment must be accorded the various situations. Room temperatures must be kept high enough to permit all operators to function at their respective posts even in the coldest weather. On the other hand, in the heat of summer, heat must be removed from resistor rooms, cable tunnels and places where heat is liberated if men are to work efficiently.

Heating of an electrical generating plant differs from factory, office and other buildings, in the fact that steam is a primary product and available at all times in large quantities. Steam, however, is so valuable for the production of power that considerable effort is made to attain economy in its use. It becomes, therefore, a question of the form in which steam is to be used to provide the necessary heat, and this leads at once to a consideration of the types of equipment best suited for such work.

Bled Steam Cheapest

In a station of modern design, there is available highly superheated steam, saturated steam and steam bled from the turbine at various stages during expansion to condenser pressure. Also, many stations operate on the deaerating cycle, wherein one of the extraction heaters operates at or slightly above atmospheric pressure and receives, in addition, exhaust steam from various turbine driven auxiliaries. The pressure in this heater is kept fairly constant even under load fluctuations, and the line to this heater operating at 1 to 10 lb. gage becomes at once a source of heat for the heating system.

Similarly, when a closed feedwater system is used, some one of the bleed points of the main turbine will usually be available as a source of low pressure steam. Bled steam is, therefore, about the cheapest source of steam for heating, the steam having already performed work in the main turbine or auxiliary turbines.

Considering the various methods of heating next: we have the hot water system, steam system and hot air system. The last has found little application in the central station as the main source of heating, probably because of the impossibility of arranging ductwork to miss the maze of piping in the station, friction heads involved with a large number of turns and offsets and the length of ductwork. The merits of the other two systems are many and require detailed consideration.

Steam bled from the main turbine is the usual source of heating steam. Extracting steam for heating does not increase materially the steam extracted for feedwater heating, and similar bleed points on the main turbines may be interconnected to form a reliable supply source.

When steam is taken directly from the steam line serving the deaerating heater at some 5 lb. gage, a main can be located in the turbine room and boiler room basement, either as a single line with branches or as a ring header. Risers are then run to radiators located at various desirable points and hand valves as well as air vent valves provided at each radiator and condensation traps at the outlet of each radiator.

Where the pressure in the supply line is maintained at 5 lb. or above, it is usually sufficient to trap and gravitate all returns to a distilled water storage tank at a low point in the basement. In case a steam supply pressure at atmospheric pressure or slightly above is available, a vacuum system can be installed very readily, the return condensation lines from radiation being under a definite vacuum controlled from a vacuum return pump. Several good motor driven vacuum pumps are available which maintain a desirable vacuum in a return condensation chamber adjacent to the pump, remove non-condensable gases, vent them to atmosphere, and return all condensate collected

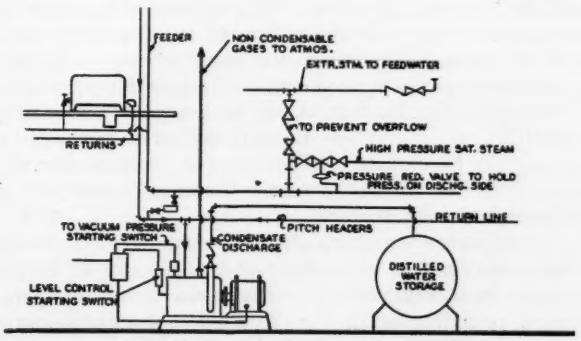


FIG. 1. SCHEMATIC ARRANGEMENT FOR EXTRACTING STEAM FOR HEATING AND USE OF VACUUM PUMP ON RETURN SYSTEM

according to level regulations to a central distilled water storage.

In Fig. 1 is shown schematically an arrangement for extracting steam for heating and a vacuum pump on the return system. The pump is automatic in starting and stopping, and therefore requires little attention. The few electrical controls, such as line switch and pressure or vacuum starting switch, are best mounted near by the pump unit. When the source of steam for heating is from a bleed line of the main turbine not interconnected with the exhaust of steam driven auxiliaries, the extraction pressure will vary with load and must be supplemented by high pressure steam. This is readily accomplished as shown in Fig. 1 by an interconnection with the high pressure steam supply through a pressure reducing valve designed to maintain the desired system pressure on its discharge side. To prevent back flow of high pressure steam into the main turbine, a check valve isolated with gate valves is provided, as shown. Saturated steam may well be used as high pressure steam from the saturated steam header to avoid using special metals to withstand high temperatures.

Hot Water System

Ordinarily the motive head resulting from temperature difference is not sufficient to provide the required hot water circulation for heating purposes and a forced circulation system is more commonly employed. A common arrangement of such a system is shown schematically in Fig. 2. As in the case of the steam system, the source of steam is bled steam interconnected with high pressure steam. A closed heater similar to extraction heaters employed in the feedwater system is used, the latent heat of the steam being given up to the water under forced circulation. Good design calls for two circulating pumps, either one of which is capable of handling the maximum heat load. It is customary to allow a temperature drop of 20 to 30 deg. through a radiator. Then, allowing for line losses, the temperature difference of water across the heater may be as much as 40 deg.

Since water expands upon heating, it is necessary to provide allowance in the shape of an expansion tank. If the system is to be operated with an outlet temperature greater than 212 deg. F. the tank must be closed, but otherwise it is open to the atmosphere, and, as in a simple gravity system, is located above the highest radiator and placed on the suction side of the circulating pump. This is advisable, since in operation the head builds up on the discharge side of the pump and backs down on the suction side, less column height being required on the suction side. The drainage from the heater can be trapped to a nearby distilled water storage tank if sufficient pressure is available to elevate the condensate. The higher the heater is set in the basement the more readily it is drained to such storage.

Temperature control of such a system can be nicely laid out by first controlling the steam supply to the heater in accordance with outlet heater water temperature, as indicated in Fig. 2. This thermostatic regulation can further be adjusted periodically at a central control box located, for example, near the circulating pump motor controls. Also by installing variable speed a.c. or d.c. motors, the rate of circulation can be varied and therefore the amount of heat released, since heat transfer is a function of velocity. Experience has also demonstrated that no matter how well proportioned the various branches of the circulating system may be the friction drops will not be the same, and it is necessary to resort to variable elements of fluid resistance placed at the junction of each branch from the service main to equalize flows and heat distribution. These resistances are adjusted in operation for best results. Small piping runs up the friction head too rapidly, and 1¼-in. pipe may be considered a minimum for such work. Velocities of flow of 6 to 8 ft. per sec. will give satisfactory circulation without excessive friction drops.

Steam Requires Less Radiation

In comparing the hot water and steam system, certain features stand out. The steam system for the same heat load in B.t.u. per hr. will require less radiation surface, the coefficients being approximately 150 to 170 B.t.u. per sq. ft. per hr. for hot water to air, and 250 to 270 B.t.u. per sq. ft. per hr. for steam to air. Also the steam system is simpler, as it involves only trap returns in the case of a relatively high supply pressure. For a steam system with low supply pressure, the installation of a motor driven vacuum pump adds to the cost of the system one-quarter to one-third of the cost of the radiation installed in small stations and less in larger plants. Lower pressure steam can be used, however, and return lines made smaller.

While the first cost is somewhat against the hot water system, involving as it does a heater and pumps, its flexibility is very great. In mild weather the water outlet temperature can be set for a minimum and water circulated slowly. In cold weather the system can be pushed to a maximum, although it is not necessary to design for extreme conditions.

Desirable Working Temperatures

The basis of proportioning the size of a heating system is very much the same as a factory or office building. Offices and operating rooms where men must live and work are usually figured for a comfortable temperature of 70 to 80 deg. F.; stairways, switch rooms and store rooms in the office section at 60 deg.; and various points in the turbine room basement at 60 to 65 deg. F. The outside temperature is usually taken as an average low figure over a period of years and depends upon latitude.

It is not as important to keep the turbine room basement warm as it is to avoid humidity and condensation. The problem of condensation on the turbine room sky lights is troublesome and warrants special attention in designing the heating system. Considering the usual great depth of the turbine and boiler rooms, the problem of adequate heating would be great were it not for radiation. It can roughly be said that radiation from the boiler walls and furnace is sufficient to keep the boiler room comfortable in winter. Allowance could be made in the past for the heating effect of main generator losses when the cooling air was discharged upwards into the turbine room. Since generators are all operated as self-cooled systems today, no benefits as far as heating is concerned are derived

from their heat losses. On the other hand, the radiation from the high pressure end of the turbine, no matter how well lagged, provides enough heat for comfortable operation around the unit. It then remains only to heat certain portions of the basement and office sections.

Power House Ventilation

Adequate ventilation for a station is a problem usually most acute in the heat of summer. The boiler room becomes heated and the temperature gradient increases with distance above the operating floor. Ventilation sash is, therefore, necessary immediately over the boilers. This is often supplemented by exhaust fans which are located near the ceiling of the boiler room and discharge through the roof. Combination fans can be arranged to exhaust in summer and also pull heated air from the turbine room in winter and discharge it into the boiler room where it becomes suction air for the forced draft fans when mounted at a high elevation.

Unit Heater Dries Basement

Turbine room basements are inclined to be humid, due to the amount of exposed circulation water piping which carries colder water than the surrounding air and thus acts as condensation surfaces. A certain amount of water also drips from machinery and the condenser onto the floor. One way of handling this problem is to install at some out of way point a forced circulation hot air unit arranged with tempering coils. Air is drawn from a cooler region, either from the outside or near the turbine room main floor, tempered by passing across steam heated coils, and then discharged through a main duct and down discharge ducts at various points where the humidity runs high. Heat system steam can be used for the tempering coils and condensation trapped to distilled water storage, the temperature of the tempered air being controlled thermostatically.

It is common practice to place resistor and rheostat elements for various motors in subbasement vaults and isolated rooms. Under load the amount of heat given off cannot be taken care of through natural ventilation or radiation, and men cannot work efficiently in such an atmosphere. Here the problem is largely one of adequate forced circulation to keep the temperature rise down to an economical minimum. Individual room motor driven exhausters or propeller type fans may be selected on a heat released basis to move sufficient air to maintain a 10 to 15 deg. temperature rise. Cable pits and tunnels may be ventilated in the same manner and sometimes justify a small central ventilation system with ductwork. Since the total temperature is greatest in summer, the coolest source of air available should be used to cut down the volume handled.

Battery Room Ventilation

Battery rooms, where batteries are located for furnishing current for emergency lighting, require separate consideration. Fumes are generated by electrolytic action and should not be allowed to find their way into the station proper. To remove fumes and to allow inspection, an individual duct or stack may

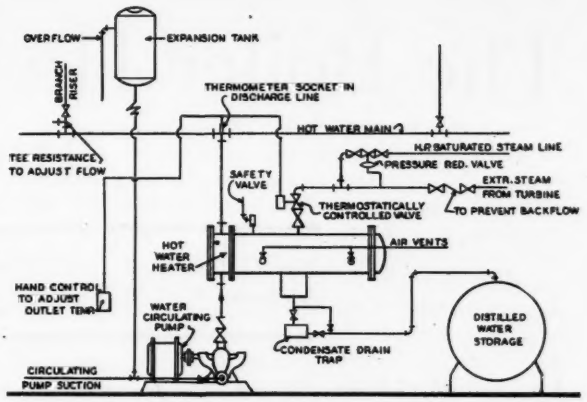


FIG. 2. DIAGRAM OF PIPING FOR FORCED CIRCULATION OF HOT WATER IN HEATING SYSTEM

be run from the high point of the room to a point above the roof or out of doors, this duct being incorporated in the building wall.

To provide draft for natural ventilation, an opening must be provided near the floor of the battery room, though it is usually safer to have no communication and to use a small exhauster fan to discharge the fumes and gases out or up the stack and to locate the motor control exterior to the battery room. The capacity of the fan is probably best based on a certain number of air changes per hour. Occasionally electrical equipment is located in vaults which must be ventilated but there is also an explosion hazard. Louver type dampers which close upon an increase of pressure should then be installed in the separating wall.

Substation Space at a Premium

Substations near or connected with the station and containing motor generators and rotary converters must be properly heated and ventilated also. Since the building is usually relatively smaller than the central station and clean air is essential, an air blast system will perform satisfactorily. Air is drawn in through filters, and in the winter the cold air is first tempered at constant moisture content, then washed and saturated, and finally heated again to the desired temperature and humidity. A small heating boiler is required and the condensate is returned to it. The outlet temperature of the air is thermostatically controlled from a thermostat in the fan discharge duct, and the riser ducts may be brought up inside or along the building walls, and air discharged down through louver openings. The capacity of such a system is based upon the heat losses of the building, but consideration must be given to the heat given off by the generating machinery, which is usually air cooled. The head required for such a system does not exceed 1 to 1½ in. of water. Space is usually at a premium and the unit must be compact and located in an out of way corner. There are several excellent units available meeting all these requirements. Such a unit requires little attention, is flexible according to temperature demands, acts as a ventilating system in summertime, and is in reality an air conditioning apparatus.

POWER PLANT ENGINEERING March 1934

The Boiler Heat Balance and its Calculation

Part I. Graphical Calculation Based on Average Values Give Accuracy Well Within Test Limits. By Albert T. Canfield*

IN THE ANALYSIS of boiler efficiency tests, and in the computation of efficiency guarantees, the use of a heat balance is essential. In the testing of boilers, only by its use can we determine the sum of the otherwise indeterminable or unaccountable losses, such as the unconsumed combustible in the flue gas and the setting "radiation" loss. An evaporative test for determination of efficiency is of little value without determining, in addition, the unaccountable losses, for these are the criteria of operating efficiency, and from these alone can we definitely determine any deficiency in operation or furnace design which may militate against obtaining the best possible performance of a steam generating unit.

Let us suppose, as an illustration, that a modern pulverized fuel fired boiler, operating above normal rating, yields a test efficiency of 78 per cent, and that the computed heat balance indicates an unaccountable loss of 7 per cent. We know that the sum of the carbon and radiation losses should be less than this, and that accordingly the heat balance has disclosed the existence of a preventable loss which must be located and corrected.

It is customary, in predicting the operating efficiencies of a prospective steam generating unit, to make a heat balance computation based upon an ultimate coal analysis and known or assumed operating conditions. In such cases as this, the percentage of unpreventable losses are calculated, and the sum of these, plus an assumed radiation and carbon loss, are subtracted from 100 to obtain the expected operating efficiency.

Difficulty of obtaining ultimate analyses of fuels under consideration for heat balance computation, generally necessitates submitting a sample to a chemist for analysis. The time, inconvenience and expense involved in this procedure is usually a stumbling block in computations of this nature, and especially so if they must be made frequently and for widely varying types of fuels. When proximate analyses are available, the percentage of the constituent elements represented in the ultimate analysis may be determined approximately from these by use of various empirical formulas or graphs, the accuracy of which may be within an allowable tolerance provided they are applied within the limits of fuel types for which they were designed.

Given, however, an ultimate analysis, either computed or determined by a chemist, there still remains considerable computation to determine the remaining data from which the various losses comprising the heat balance are computed, with the result that the time required for the entire problem, provided resort is not had to abbreviated methods, will extend into a matter of hours.

With the view of obviating, in each case, the necessity of an ultimate coal analysis, and to develop a rapid method for obtaining a heat balance, which would yield results within a tolerance allowable in cases other than those requiring extreme precision, the writer developed the graphical method described in the following paragraphs and illustrated in the accompanying charts.

Data Ordinarily Required

When boiler and furnace efficiency is not to be computed from a heat balance by the usual method, or the magnitude of the unaccountable losses are to be determined following an efficiency test, the following data is necessary: (1) Ultimate coal analysis; (2) initial moisture content and temperature of both the fuel and combustion air (initial temperature assumed throughout this paper to be 70 deg. F.); (3) final temperature of gas leaving heat absorbing surfaces; (4) volumetric flue gas analysis. From this data the accountable losses listed below can be determined:

(1) Dry gas loss; (2) hydrogen loss; (3) moisture in coal loss; (4) moisture in air loss.

These losses are unpreventable, and will not vary provided the coal analysis, initial and final fuel and air temperature, and the gas analysis, are constant. (An exception to this statement is the dry gas loss, which will vary with the percentage of unconsumed combustible, irrespective of a constant CO_2. The effect of this unconsumed combustible on the assumed or actual percentage of CO_2, and upon the computed dry gas loss, is disregarded in this system of heat balance determination, the resulting irregularities being absorbed in the indeterminable, or unaccountable, losses.) The moisture in air loss is not considered hereafter as a separate determinable loss, but is included under "unaccountable losses" due to its small magnitude and relative unimportance.

To complete the heat balance and obtain the total losses, which are subtracted from 100 per cent to arrive at the combined boiler and furnace efficiency, it is necessary to add to the aforementioned determinable losses the following indeterminable losses: (5) Unconsumed combustible loss in flue gas or ash; (6) setting radiation loss; (7) unaccountable loss. These

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are frequently grouped under one heading, unaccountable losses, inasmuch as the unconsumed combustible loss in the escaping gases is difficult to accurately determine, and the setting radiation loss cannot be directly measured.

These individual losses, or their sum, should be of small magnitude in well designed installations, and, in forecasting efficiencies, may be estimated with sufficient accuracy to yield a negligible error. In boiler tests, as stated previously, they represent the difference between 100 per cent and the sum of the combined efficiency plan plus the determinable losses.

Typical Ultimate Analyses

If we examine the ultimate "as received" analyses of coal samples ranging in value from the semi-bituminous of the Eastern field to the lignites of North Dakota and Texas, we will note a marked tendency toward a fairly uniform variation between the ratio of the constituent elements of the coals to their calorific value. We will note for example, that as the quality, or calorific value, per pound decreases, the percentage of carbon and nitrogen decreases; the percentage of total hydrogen and oxygen increases; and that the percentage of ash shows a tendency to increase until, at least, the lignites are reached. Similarly, the moisture content varies from less than 5 per cent in the semi-bituminous coals to around 35 per cent in the lignites. The sulphur content is independent of the B.t.u. value of the coal.

By taking several hundred ultimate analyses of different American coals and plotting the percentages of their constituents against the B.t.u. value of each sample, a set of curves as shown in Fig. 1 is obtained. While these curves present only an average, or typical percentage of each element for any particular B.t.u. value coal, it was found that a heat balance based upon the percentages as read from the curves, and compared to one computed from an actual analysis of a coal having the identical calorific value, will, in the great majority of cases, give a total determinable loss within the limits of allowable tolerance.

Heat Loss Through Setting

There are so many factors which control the extent of the unaccountable losses that it is possible only to give a very casual approximation of what their magnitude should be at various boiler ratings.

In a well designed and operated plant, the heat loss from the setting should represent the major portion of the unaccountable loss, and the unconsumed combustible loss should make up the balance, with the exception of the moisture in air loss, which is considered in the application of these charts as being a portion of the unaccountable loss.

If we attempt to arrive at the heat loss through the setting by computation, treating it as a simple problem in heat transmission, we have, on the outside of the walls a fairly constant room temperature, but on the inside we are confronted with a variable furnace and boiler pass temperature with, usually, different forms of wall construction throughout the setting. The problem is still further complicated in cases where water walls, air cooled walls, insulation, and metal wall casing are present. The necessity of making many assumptions in order to arrive at a conclusion, renders the computation so laborious and susceptible of error that this loss is usually estimated with an accuracy sufficient for forecasting efficiencies or checking unconsumed combustible loss after the accountable losses are determined.

Heat loss through a boiler setting naturally increases as the rating increases, but expressed as a percentage of the total furnace heat input, the reverse is true. Thus the radiation loss at zero per cent boiler rating is represented approximately by the weight of coal required to maintain steam pressure with a banked fire, multiplied by the calorific value of the coal per pound, and at this load represents 100 per cent of the total heat input to the furnace. Expressed in B.t.u. per hour, however, the loss for the banked condition is but a fraction less than that at higher ratings. At ratings between 200 per cent and 300 per cent in a well designed setting, the heat loss will usually be between 3 per cent and 2 per cent of the total heat input to the furnace, and above 300 per cent should be less than 2 per cent of the heat input.

In small boilers the ratio of steam output to square feet of wall surface is usually less than for larger boilers, and the per cent heat loss through the setting is accordingly somewhat higher than for the larger units. The following table is fairly representative of setting heat losses for modern, well designed installations.

Boiler rating, %	100	150	200	250	300	350	400
Heat loss through setting, %	5	3.5	2.5	2.0	1.8	1.6	1.4

In stoker fired furnaces the unconsumed combustible in the ash is a function of the proper application, design, operation, fuel type and rating, and may vary from a staggering figure where the worst conditions exist, to a remarkably low percentage in large, modern installations.

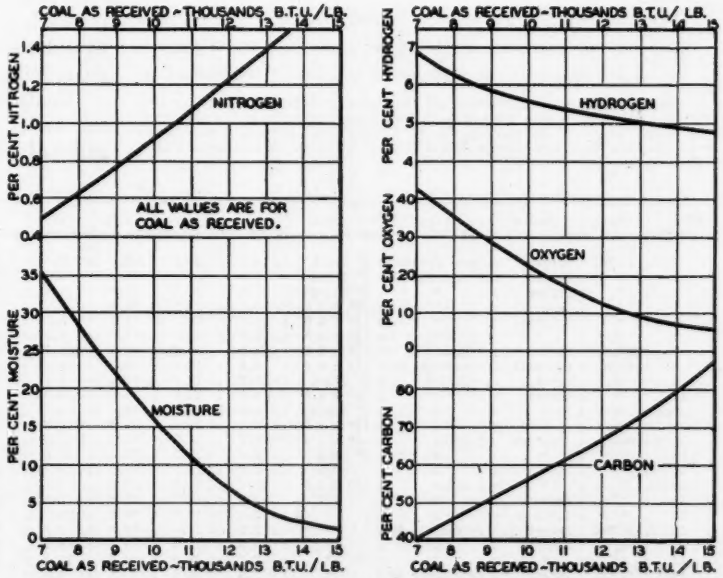

FIG. 1. DATA FOR DETERMINING THE ULTIMATE ANALYSIS OF A COAL FROM THE HEAT CONTENT

POWER PLANT ENGINEERING March 1934

Caking Action of Coal On Stokers

By
J. F. Barkley[2] *and*
L. R. Burdick[3]

Laboratory Agglutinating Tests Serve Coal User and Help in Anticipating Coal Burning Characteristics[1]

LABORATORY AGGLUTINATING VALUE tests of coals consist essentially of carbonizing for 20 min., at a temperature of 950 deg. C. (1742 deg. F.), chosen 20 gram mixtures of finely ground coal and sand. These values are expressed in terms of the crushing strength in kilograms of the resulting carbonized lump or button.[4] This laboratory test has been developed to give information regarding the caking and coking properties of coal. It might be classed as another item of laboratory analysis to be considered and interpreted by the coal user as he now makes use of the proximate analysis or the ash fusion.

Agglutinating values were determined for twenty-five different coals purchased by the Government for use in many different types of coal-burning equipment. Observations as to "caking" tendencies and coke formation were made on these coals as they were burned in the various types of equipment under regular operating conditions. From a study of the data it appears that the agglutinating test can be made to serve the experienced coal user as a further help in anticipating coal-burning characteristics.

The coals used, the agglutinating values and the operating observations are given in Tables I and II. Figure 1 shows some typical plots of agglutinating values. In Table II the coals are divided in two groups, those used on natural draft equipment and those used on forced draft. The natural draft equipment included ordinary hand-fired grates, down-draft grates, various types of inclined grate stokers, and one traveling grate stoker. The forced draft equipment consisted of various types of underfeed stokers—side dump and end dump. With a few exceptions, each coal was used on all the different types of equipment of its group.

Caking Definitions

To attempt to express very clearly by words the operating observations as to "caking" tendencies and coke formation is rather difficult. Word meanings and measuring standards have not been developed. It was decided for the purpose of this investigation to express the rapidity of caking by four expressions, given in their relative order as follows: Quickly, fairly quickly, rather slowly, and slowly. To express the nature of the coke bed formed the expressions heavy, fairly heavy, rather light, and light were used. For example, a "heavy" coke bed or mat would mean one that had a relatively high persistence of mat formation stopping the air flow; a "light" coke bed would mean one that readily formed into small masses, permitting the air to go through.

Coals of each group of Table II are arranged in the order of the agglutinating values at a sand-coal ratio of 18 to 1. From a general study it was found

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[4]For a detailed description of the laboratory test used by the Bureau of Mines see paper entitled "Agglutinating Value Test for Coal," by W. A. Selvig, U. S. Bureau of Mines, and others read before the American Society for Testing Materials, June, 1933.

Coal Item No.	State	County	Seam	Size	H_2O	Vol.	F.C.	Ash	S	Dry B.t.u.
1	W. Va.	Preston	Upper Freeport	2" N & S	4.1	21.5	69.1	9.4	0.7	14,150
2	"	Mercer	Pocahontas #3	2" Slack	2.3	18.5	73.9	7.6	0.6	14,580
3	"	McDowell	"	2" Slack	3.0	21.9	72.7	5.4	0.5	14,940
4	"	Tazewell	"	1½" N & S	3.5	21.5	72.5	6.0	0.7	14,790
5	"	McDowell	"	1½" N & S	2.8	22.0	71.7	5.3	0.5	14,810
6	"	"	"	1½" N & S	3.9	22.3	71.7	6.0	0.4	14,840
7	Pa.	Somerset	C Prime	1½" N & S	2.6	18.8	69.9	11.3	2.7	13,820
8	W. Va.	McDowell	Pocahontas #3	1½" N & S	4.1	19.8	75.2	5.0	0.6	15,030
9	"	Raleigh	"	2" Slack	2.7	17.4	76.3	6.3	0.8	14,740
10	"	Mercer	"	1½" N & S	5.7	19.6	74.4	6.0	0.6	14,830
11	"	"	"	2" Slack	3.2	17.3	76.0	6.7	0.6	14,750
12	"	"	"	1½" N & S	5.0	19.4	75.3	5.3	0.6	14,960
13	Pa.	Somerset	C Prime	1½" N & S	2.7	16.6	74.4	9.0	0.9	14,260
14	"	"	B	2" N & S	2.4	17.3	70.1	12.6	2.1	13,720
15	"	"	D	R/M	2.8	16.5	76.6	6.9	0.7	14,680
16	"	"	C Prime	2½" N & S	3.7	16.4	74.3	9.3	0.8	14,240
18	"	Cambria	B	R/M	3.3	18.4	75.5	6.1	1.6	14,830
19	"	Indiana	B	"	2.6	28.3	63.0	8.7	2.0	14,310
20	W. Va.	Mercer	Pocahontas #6	"	2.9	19.8	75.0	5.2	0.7	14,980
21	Pa.	Cambria	B	"	2.5	18.9	74.5	6.6	1.1	14,690
22	"	"	B	"	3.6	18.3	71.3	10.4	1.4	14,060
23	W. Va.	Mercer	Pocahontas #3	"	3.5	16.6	77.4	6.0	0.5	14,850
24	"	McDowell	"	"	2.8	18.0	74.8	7.2	0.5	14,610
25	Wyoming	Sweetwater	Rocksprings #1	3" x 5" Egg	6.1	42.1	53.4	4.5	0.9	13,630

TABLE I. LOCATIONS OF MINES AND ANALYSIS OF COALS USED IN TESTS

that the lower as well as the higher sand-coal ratios, although showing the same tendencies, were more erratic as far as comparison with operating results was concerned than the middle parts of the curve as 18 or 22 to 1. This may be due in part to the laboratory test itself, the lower value ratios frequently forming abnormal buttons with globular air spaces. The higher sand-coal ratios, used by some laboratory investigators, particularly in England, that gave an agglutinating value of 1 kilogram or ½ kilogram were rather difficult to determine accurately, the agglutinating value curve becoming nearly horizontal at these points.

Figure 2 shows the 18:1 agglutinating values plotted against the operating observations. With the exception of point No. 24 the points of the plots for natural draft equipment show a relationship, the heavier coke formations occurring with the higher agglutinating values. Nothing particularly peculiar was noted in the burning action of coal No. 24; its agglutinating value at 18:1 is quite low, however, in relation to its value at 22:1. In the operation of the usual down-draft fuel-burning equipment the caking characteristics of the coal are especially important if the finer sizes, such as slack or run-of-mine, are to be used. Coals having high agglutinating values on these tests were quite satisfactory for this purpose, and those having low were unsatisfactory, the transition point apparently being in the 6.0 to 6.5 kilogram zone. Coal No. 25 is given to show an extreme case of a western coal that is very unsatisfactory in this regard. Certain coals quite satisfactory for down-draft equipment will lose their caking tendencies when stored for a period. This action has also been found in the determination of agglutinating values.

Points of the plots for forced draft equipment give a more erratic relationship than those of the plots for

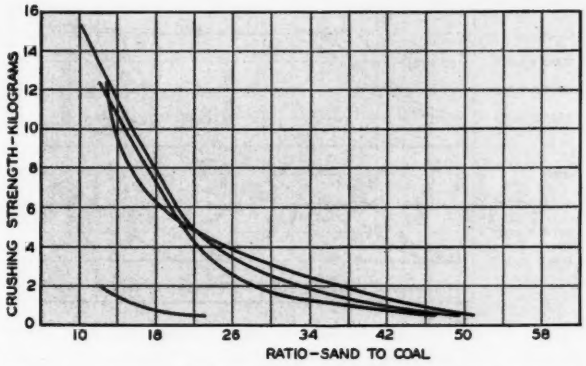


FIG. 1. CURVES SHOWING TYPICAL SHAPES OF AGGLUTINATING VALVES FOR DIFFERENT COALS

natural draft. Coals No. 15 and No. 2 are especially out of line. Both of these coals required a rather high furnace temperature for effective burning action. Coal No. 15, tried on both groups of equipment, gave a burning action for natural draft quite in keeping with its agglutinating value but under forced-draft conditions burned like a different coal. Coal No. 2, with a high agglutinating value, gave a slow action under the highest temperatures tried. Its mat formation ranged from light to fairly heavy on the forced-draft equipment, depending upon the movement and the time element of heating. This coal was far more sensitive to these factors than any of the others tried on the forced draft.

To correlate the agglutinating value test with coal burning is probably a problem similar to the one of correlating the ash fusion test that has preceded it. Coal is a complex substance and consistent relationships concerning it are nearly always confined to some

TABLE II. AGGLUTINATING VALUES AND OBSERVATIONS OF COALS GROUPED ACCORDING TO METHOD OF FIRING

Coal Item No.	Agglutinating Values Kilograms				Sand to Coal Ratio at which Agglutinating Value equals		Operating Observations	
	Ratio - Sand to Coal				1 Kg.	½ Kg.	Rapidity of Caking	Nature of Coke Mat
	10:1	14:1	18:1	22:1				
Group "A" Used on natural draft equipment								
18	15.4	11.4	7.9	4.9	42	49	Quickly	Heavy
19	x	x	7.5	4.7	44	54	"	"
5	x	9.9	7.4	5.0	44	53	"	Fairly Heavy
3	14.8	11.6	7.4	4.7	43	51	"	Heavy
20	x	9.6	7.3	5.0	44	51	Fairly Quickly	Fairly Heavy
21	x	12.4	7.1	4.4	40	48	Quickly	" "
22	x	10.4	6.8	4.1	42	56	"	Rather Light
8	x	10.2	6.7	5.1	46	52	Rather Slowly	Light
9	x	10.4	6.7	4.5	37	42	Fairly Quickly	Rather Light
10	x	9.7	6.7	4.3	44	53	" "	Fairly Heavy
11	x	10.6	6.6	3.9	38	43	" "	" "
23	x	10.6	6.4	3.0	32	55	Rather Slowly	Rather Light
12	x	9.6	6.2	4.9	45	50	" "	Light
24	x	9.3	5.8	3.9	36	41	Fairly Quickly	Fairly Heavy
15	x	8.4	5.2	3.3	34	41	Slowly	Light
25	x	1.4	0.7	0.5	16	22	-	-
Group "B" Used on forced draft equipment								
1	x	11.7	8.3	5.0	40	49	Quickly	Heavy
2	x	11.4	8.2	5.8	40	44	Slowly	Fairly Heavy
							"	Light
18	15.4	11.4	7.9	4.9	42	49	Quickly	Heavy
3	14.8	11.6	7.4	4.7	43	51	"	"
4	x	11.0	7.4	4.8	46	55	"	Fairly Heavy
5	x	9.9	7.4	5.0	44	53	"	" "
6	x	10.2	7.2	4.6	46	60	"	Rather Light
7	x	10.5	6.8	3.9	34	39	Slowly	Light
8	x	10.2	6.7	5.1	46	52	Fairly Quickly	Rather Light
9	x	10.4	6.7	4.5	37	42	" "	Fairly Heavy
10	x	9.7	6.7	4.3	44	53	Quickly	" "
11	x	10.6	6.6	3.9	38	43	Fairly Quickly	Heavy
12	x	9.6	6.2	4.9	45	50	Rather Slowly	Rather Light
13	x	10.0	5.6	3.3	35	41	Slowly	Light
14	x	9.1	5.5	3.2	33	39	"	"
15	x	8.4	5.2	3.3	34	41	Quickly	Fairly Heavy
16	x	8.7	4.7	2.7	31	34	Slowly	Light

x - abnormal button

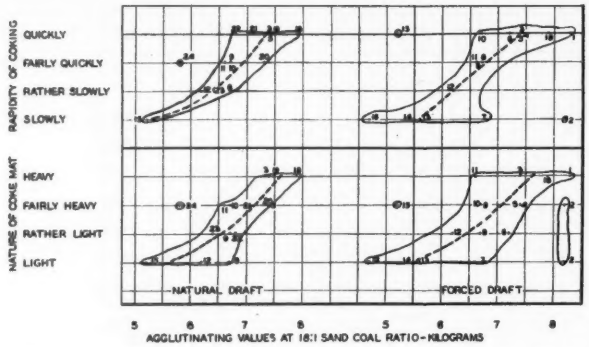


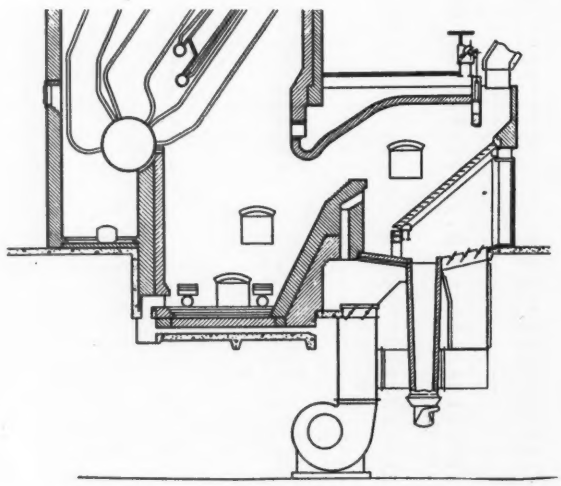
FIG. 2. AGGLUTINATING VALUES AT 18:1 SAND-COAL RATIOS PLOTTED AGAINST OPERATING OBSERVATIONS

particular grouping or set of conditions. Before the problem is completely solved operating experience covering all conditions and all coals will be needed.

Furnace for Wood Waste

LUMBER MANUFACTURING, an important industry of the Northwest, is accompanied by unavoidable waste in the form of sawdust, shavings, end cuts, blocks and slabs. As an economic factor it is desirable to use this waste in the furnaces of power boilers. This is done with considerable success, using hogs for the larger pieces, one of the successful installations, that of the Coos Bay Plant of the Mountain States Power Co. at Marshfield, Ore., being described by L. D. Gilbert, of the Byllesby Eng. & Mgt. Corp., before an engineering convention of the company.

The history of this plant goes back to 1924 and covers many designs. The latest, shown by the illustration, is similar in design to that used in a boiler installed in 1929, although some changes have been made. The location of the forced draft fan is directly under the bridge wall duct as a greater quantity of air is required to pass through the bridge wall than through the grates. No dump grates are used in this boiler. Instead at the end of the inclined grates a pit is installed. In the front wall of this pit are arched openings through which air for the combustion of fuel is admitted and through which ash is removed.



HOGGED FUEL FURNACE WITH FORCED DRAFT

To overcome difficulties experienced in the previous boiler due to the bridge wall openings being slagged over with melting ash the nose of the bridge wall in the new boiler was designed with an overhanging lip. Introduction through the bridge wall of the major portion of air necessary for combustion is a deviation from previous practice and a step to more efficient burning.

Coal Distribution in Stoker Hoppers

SCREENING tests were recently made at the Marion, O., power house of the C. D. & M. Railroad to determine the distribution effectiveness of two types of non-segregating distributors serving two 866 hp. B. & W. boilers, fired by 9 retort Westinghouse underfeed stokers. Each boiler has three distributors and chutes. For the purpose of sampling each of the three distributors on each boiler was divided into six stations 9 in. wide. A sample taken at each station across the column of coal represented a complete cross section of the coal feeding through the hopper.

Data in the table shows the weights calculated as a percentage of each size at each station compared to the total amount of coal of that size fed to each chute. With six stations to a hopper the theoretical perfect distribution for each size would be 16.6 per cent so that variations plus or minus on this amount indicate the departure of the performance from the ideal. Tests were made for the Fairfield Engineering Co. by the Commercial Testing & Engineering Co.

TABULATION OF TESTS SHOWING WEIGHT OF EACH SIZE DISTRIBUTED TO EACH STATION AS A PERCENTAGE OF THE TOTAL WEIGHT

Boiler No. 4

Chute No. 1

Station No.	1	2	3	4	5	6
Over 1¼"	4.4	8.8	24.4	31.4	22.2	8.8
Through 1¼"	7.7	23.9	23.9	26.3	12.5	5.7
Through ¾"	14.9	17.1	17.5	17.5	18.1	14.9
Through ¼"	18.7	17.4	14.5	16.1	15.1	18.2

Chute No. 2

Station No.	1	2	3	4	5	6
Over 1¼"	6.4	15.5	31.0	23.9	15.5	7.7
Through 1¼"	7.1	13.0	26.0	23.0	17.9	13.0
Through ¾"	13.9	15.8	19.8	16.9	16.1	17.5
Through ¼"	18.3	18.6	14.5	15.3	16.4	16.9

Chute No. 3

Station No.	1	2	3	4	5	6
Over 1¼"	.0	24.1	27.5	20.6	20.6	7.2
Through 1¼"	4.1	13.2	23.1	23.1	20.0	16.5
Through ¾"	14.6	17.5	17.5	17.9	17.0	15.5
Through ¼"	18.3	18.3	17.4	15.0	16.0	15.0

Boiler No. 6

Chute No. 1

Station No.	1	2	3	4	5	6
Over 1¼"	16.9	11.2	18.3	22.4	18.3	12.9
Through 1¼"	14.1	16.0	19.0	20.0	18.1	12.8
Through ¾"	17.4	17.5	17.4	15.7	14.6	17.4
Through ¼"	20.3	12.8	15.8	16.1	14.4	20.6

Chute No. 2

Station No.	1	2	3	4	5	6
Over 1¼"	18.3	19.7	12.6	16.2	16.9	16.9
Through 1¼"	18.1	15.7	18.7	19.8	14.0	13.8
Through ¾"	17.9	18.2	20.9	15.6	14.7	14.7
Through ¼"	19.6	10.6	12.6	17.4	16.1	23.7

Chute No. 3

Station No.	1	2	3	4	5	6
Over 1¼"	10.2	14.2	16.3	18.6	14.2	26.5
Through 1¼"	11.4	16.6	14.5	21.8	18.0	17.7
Through ¾"	17.4	16.5	16.5	16.8	15.4	17.4
Through ¼"	21.7	12.6	17.4	17.8	13.5	17.0

LIGNITE as Fuel *in Canadian Boiler Plant*

Peculiarities of Combustion Characteristics Demand Special Furnace Design and Unusual Methods of Handling Fires. By Edward Green

FROM COAST to coast economic conditions have forced steam plant owners to seek the cheapest available methods of making steam. When this situation faced the Northern Public Service Corp. of Winnipeg, Man., the only alternative was to build another plant which is known as the Renfrew plant. It was decided that Saskatchewan Lignite (or Souris) would be the fuel used. It was cheap and easily available. Other coals could not compete with it in price, so with this end in view the plant was designed to burn lignite. Other fuels could be used if necessary but Souris was the primary selection.

The boiler chosen was a Kidwell, four drum, bent tube, with a heating surface of 8770 sq. ft. This boiler is capable of delivering steam at a working pressure of 155 lb. per sq. in. and 50 deg. superheat. The lower drum is set 15 ft. above the grates but the center of the lower tube bank is approximately 19 ft. above the fire. The furnace and entire boiler setting is built of firebrick throughout. The reason given for this was, the difference in expansions between common and firebrick would cause cracking and as the cost of firebrick was not excessive, and thick walls were not required owing to low furnace temperatures due to the burning of lignite it was more economical.

Fuel burning equipment consists of four Reco 26-in. sprinkling type mechanical coal feeders, driven by a Murphy steam engine through a Reeves transmission, 200 sq. ft. of Pyramid grates and four Sturtevant turbine blowers. The grates are 12 ft. 6 in. long and approximately 4 ft. wide. Four sections of these make up the grate area. Each section is halved making it possible to dump the front or back half independently.

The ashpit is divided into four compartments and each is fitted with a steam turbine blower. The blowers are controlled from the firing floor by a master valve. Beyond the master valve are four individual valves and separate control of each blower is possible. Owing to the nature of the fuel to be fired it was not mechanically practical to install automatic control on either the damper or blowers. Ensuing practice showed this to be a wise decision.

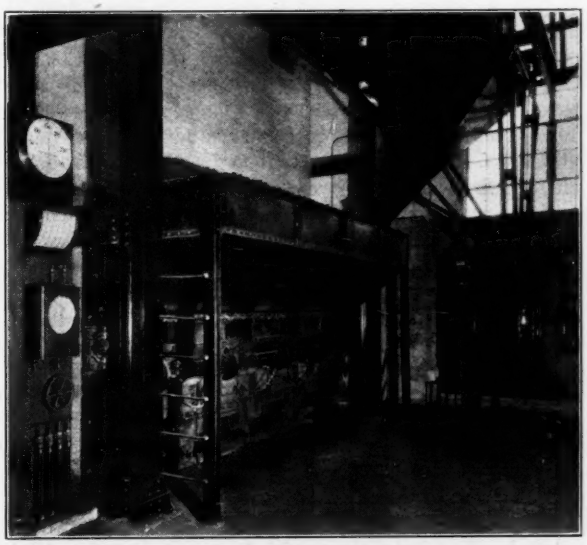
Practically speaking the burning equipment is four separate units and each can be operated independently of the other. It is possible to carry more than 100 per cent load on any three of the units.

From the feeder spindle to the back of the grates is a distance of 14 ft. and the feeders rest about 18 in. above the deadplates. No difficulty is experienced in getting a smooth even feed over this long distance and there is no tendency at present for the fuel to heap at the back and thin out at the front.

Handling the Fuel and Ash

Coal handling presents no special problem for, despite the low temperatures in this country, the coal does not freeze in the cars. Hopper bottom cars are used and they are shunted to the tracks above a concrete bunker. The bunker is fitted with shutes set at 8-ft. centers and the coal flows into the buckets of a conveyor. The coal is carried from here to a suspension bunker set above and in front of the boilers, and running the length of the building. Trippers are set along the conveyor track and the buckets can be dumped at any point in the overhead bunker. Spouts and cut-off gates serve a 2-t. weighing larry that travels on an overhead track.

Airtight doors are fitted to the ashpits. No damping arrangements are used owing to the corrosive effect on the walls of the pit. All of the ashes are drawn by hand and wetted by hose. If another boiler is installed it will be necessary to employ other methods in the handling of ash for the present system is not satisfactory.



RENFREW PLANT EMPLOYS SPRINKLING TYPE STOKERS

Starting with a clean fire, lignite and air are fed as the load requires. As the ash accumulates on the grate the ashpit pressure increases and the gage on each pit shows when sufficient resistance has been reached. The feeder for one section is cut off and the blower speeded up for a few moments. The blower is then shut down and the front half of the grate is dumped. The back half follows and the feeder is started again. Under no circumstances spread any live coal on the grate to start the new fire as it is not necessary and will only cause clinkering. The fresh coal will ignite almost at once. The blower is kept shut off until the entire bed is burning evenly when it is again started. Each section is cleaned in turn and by careful manipulation it is possible to clean fires without lowering steam pressure a pound.

Following a full season's run during which times the boiler carried an average load of 150 per cent of its rating the following facts in connection with firing lignite were discovered.

Lignite Firing Method

This fuel should never be disturbed after being placed on the firebed. Pokers and slice bars have no place in a plant burning lignite. Like wood, this fuel burns from the outside and the ash flakes off light and fluffy. The air passing through the grate keeps the ash in a porous state but if it is disturbed it will clinker. Despite belief to the contrary, lignite will form a very hard clinker and fuse quite easily if stirred in the fire. The stoker sprinkles the coal on the fire and as long as it is doing it properly no attempt should be made to speed the fire by poking.

Differing from bituminous, Souris is slow of ignition. There is much excess moisture to be driven off before combustion is possible. The increase in loads should be anticipated and the fire made up sooner than with coal. Once the fire bed is bright it will pay to fire thin and often.

Some experts will say it is possible to make an 8-hr. run without cleaning fires but such is not the case. The best operating conditions are obtained when the fuel bed is kept to a maximum thickness not exceeding 4 in. When the ash is at that depth the fire should be cleaned. At all times a free, even flow of air should pass through the grates.

Lignite requires much more air than other fuels. Complicated sets of figures can be given to illustrate this but they are of little value in actual experience. The air must pass through the fire and carry the flame at least 5 ft. beyond the fuel bed. With a properly cleaned fire and the correct amount of air the fire will be blue in color and the flame will soar and curl up into the passes. At all times try to keep the ash literally dancing on the grate.

Never attempt to burn lignite with a natural draft. It will be a failure from the start. Whether induced, or forced, mechanical draft must be used.

Overfire air is also of great importance. If sufficient air is not admitted over the fire, slag will form and run down the walls and plug the grates. It will harden here and dumping will be impossible.

Flue gas temperatures in this plant vary between 550 and 650 deg. These figures are considered low.

Some trouble was met when the feeders were first started. The long throw, 14 ft., necessitated a high spindle speed and consequently the fuel piled at the back and thinned at the front of the furnace. This was overcome by the use of the variable speed transmission but further trouble then developed when the fuel began to ridge or pile thickly at one point and thin at another. A great deal of experiment was necessary before the proper flippers or feeder blades were discovered.

Despite, this, however, the feeders still refused to fire evenly. The coal would either pile or wing to one side. Investigation showed the coal was not of uniform size and that was responsible for the trouble; ¾ to 1½-in. sized coal gave the best result. Fines, too light to catch the flippers piled on the deadplate but a series of steam jets were installed that blew these onto the fire.

These difficulties were being overcome one after another when it was seen that the fire would blacken in spots while the other part burned brightly. On the blackened spots the fuel would pile unburned. The grates were cleaned but that did not solve the trouble. It was then found that when the fire was first started the blower would blow through the front of the grate first and burn that fuel more quickly. As more fuel was added it could not keep up to the part of the grate that received more air. Shutting off the blower until the entire fire bed was burning evenly disposed of this question. To attempt to drag the blackened spots with a rake was disastrous. The entire fire required cleaning afterwards.

Soot Blowers Necessary

Lignite is different from other fuels and its peculiarities must be learned. It does not coke and its ash will not clinker if undisturbed. It can not be fired in large quantities or it will practically extinguish the fire. It must be fired thin, even and often. It is by no means a sensitive fuel, so proper allowances must be made for ignition.

On this boiler there are five soot blowers in the passes. Experiment has shown that passes should be blown at least twice during an 8-hr. shift. If this is not done the flue gas temperatures will climb at an alarming rate owing to the light ash being carried into the passes.

With a fuel showing an analysis of 8 per cent ash, 30 per cent moisture, and 7000 B.t.u. heat value, the Renfrew plant is obtaining evaporation of 4.53 lb. corresponding to an equivalent evaporation of 4.97 lb. More than 7,000,000 lb. of steam are an average weekly run, the load varying from 50,000 to 75,000 lb. per hr. An increase of 40,000 lb. is possible within 20 min. so some idea as to the flexibility of the fuel can be gained from that figure. At the present price of lignite fuel, the generating fuel costs average 27 cents per 1000 lb. of steam.

It is admitted that lignite entails a trifle more care and labor but if properly handled it will prove to be one of the most economical fuels ever used in the generation of cheap steam.

The Renfrew plant is the largest of its kind in the world burning lignite exclusively. It started as an experiment but has proved such a success that when an addition is necessary the same design will be followed throughout.

Electrical Engineers *Present Varied Program at* New York Meeting

Annual Winter Convention of the American Institute of Electrical Engineers brings forth many interesting papers and stimulated interesting discussion. Demonstration of Auditory Perspective a feature of meeting

THE 1934 WINTER CONVENTION of the American Institute of Electrical Engineers, held in New York, January 23 to 26, as usual was interesting in all its aspects and was outstanding in the effective manner in which it was run. From beginning to end, it was a well-planned, highly coördinated meeting, stimulating to those fortunate enough to be able to attend and valuable to the Institute membership and to the engineering profession as a whole for the excellence of its technical discussions. As Dr. Whitehead, of Johns Hopkins, pointed out in his presidential message at the opening of the meeting, there is something about the Winter Convention that gives it a value that other meetings during the year do not seem to have, due perhaps to the fact that the Winter Convention is principally an indoor affair with less opportunity for distraction.

There was an excellent technical program; indeed, this always is the main feature of the meeting. This year, the arrangement was slightly different from that of other years. The program was so planned as to provide three full days for the presentation of papers at technical sessions, leaving the fourth and last day of the meeting available for inspection trips to local points of interest.

Frank Sprague Honored

The meeting opened impressively with the presentation of a bust of Frank J. Sprague to the Institute by a special committee formed for the purpose. Frank Sprague is a man known to all and loved by scores of electrical men who have been associated with him throughout the years. His contributions to the electrical industry have been many, particularly in the field of transportation. He, more than any other man is known as the father of the electric railway. The formal presentation of the bust was made by Frank Hadley, president of the Interborough Rapid Transit Co.

As pointed out above, the schedule of events throughout the convention was coördinated to provide a good balance between both business and social activities. Altogether, eleven technical sessions were held in the mornings and afternoons of the first three days. In the evenings, a smoker, the Edison medal presentation, a demonstration of transmission and reproduction of music and the annual dinner dance were held. Friday, January 26, the last day of the convention, was devoted entirely to inspection trips, though arrangements were provided permitting visits to points of interest on other days as well.

Effect of Peterson Coils on Transmission Lines

The technical part of the convention opened promptly at 10:30 a. m. on Tuesday, January 23, with two sessions, one devoted to a series of papers on protective devices and the other to transportation. At the session on protective devices, interest centered largely upon a paper by J. R. Worth and J. R. Eaton of the Commonwealth and Southern Corp. and the Consumers Power Co. respectively, on Peterson coil tests on a 140-kv. system. In this paper it was shown that Peterson coils installed on part of a 140-kv. transmission system operating with the neutral ungrounded successfully eliminated a large percentage of interruptions due to line-to-ground faults which occurred on that section. Dr. Fortesque of the Westinghouse Co. in discussing this paper, while he appreciated the results of these tests pointed out that the overhead ground wire would give as adequate protection as an unprotected (by ground wire) Peterson coil system. The Peterson coil he said does not prevent lightning from entering the substation. After all, he claimed, the use of the Peterson coil should be determined by economic conditions. In his own experience the use of deion tubes had given very successful results—on one line, he knew of, such tubes had given practically 100 per cent protection.

Mr. Worth, one of the co-authors of the paper, said he was entirely in accord with Dr. Fortesque's remarks but pointed out that the Peterson coil had decided advantages in that it could be applied to an existing transmission line where it would be too expensive to install a ground wire.

At this same session, the second paper on protective devices also stimulated discussion since it involved the measurement of lighting on 4-kv. overhead circuits. This paper presented by Herman Hal-

perin of the Commonwealth Edison Co. and K. B. McEachron of the General Electric Co. described the results of 4-yr. experience in recording lightning potentials on the 4-kv. distribution system of the Commonwealth Edison Co. in Chicago. Among other things, this study showed again the advantage of the arrester ground and secondary neutral interconnection on distribution transformers. It was brought out, too, that the probability of direct strokes on urban lines is much more remote than on long transmission lines.

Opinion in regard to this paper was divided but seemed unanimous in that data of this sort was extremely necessary. There is little data available regarding distribution circuits, and before we can set up standards for insulation and protection of such circuits it is necessary to know what surge potentials are encountered. Dr. Fortesque was of the opinion that none of the surges recorded in this study were direct strokes, but that all of them were induced surges.

Transmission of Electric Power

To engineers interested in the transmission of electric power the symposium on electric power switching on Tuesday afternoon was of considerable interest. This session involved five papers, each describing the facilities at one important generating or switching station with a short introductory summary by Alfred H. Lovell of the University of Michigan. These papers were as follows: Hudson Avenue Station, by G. M. Gilt; Richmond Station, by R. Bailey and F. R. Ford; Long Beach Plant No. 3, by Kroneberg, Bulkley and Andree; Connors Creek Plant, by A. P. Fugill; and State Line Station by T. C. White. These papers created a considerable amount of discussion because of the varied nature of the systems described.

Among the first to discuss this paper was Mr. Hollister, electrical engineer of Sargent & Lundy, of Chicago. He felt that while there was a considerable divergence of opinion in regard to the merits of the respective systems, there was a tendency in all of them to utilize the unit system combining a generator and a transformer without any intermediate switches between them. He felt that in our generating systems this idea would be carried out to an increasing extent. Economy and reliability, he said, would force that result. He also seemed inclined to believe that we would see more high voltage transmission terminals at the theoretical distribution load centers. Complicated, expensive, low voltage switching schemes with interlocking arrangements might be necessary in some cases but he looked forward to the day when these interlocking devices will not be necessary.

Another thing which he said we might expect in the future was still higher voltage generators. He cited British practices in example, pointing out that in Great Britain they find it feasible to use 33 to 36 kv. and that Parsons was ready to wind generators for voltages as high as 66 kv. Circuit breakers also, he said, needed more attention. While they break the currents necessary they do not have great enough factors of safety. Instead of being far ahead of generator practice as they should be, circuit breakers are just keeping pace with generator practice.

Several of those who discussed the papers at this session emphasized the great dissimilarity in the design of each of the five switching systems described. Mr. Rand, of Westinghouse, pointed out, facetiously, that the unanimity with which each designer had presented his station was encouraging. Even when designs were based on the same specifications they were still very dissimilar. Others pointed to the "disconnects" between the generator and the first breaker as a source of weakness and trouble and were of the opinion that a more solid connection was desirable. The design of State Line Station came in for considerable commendation. Many seemed to thing that State Line Station had done much to make outdoor metal clad switch gear reliable.

One of the representatives of the Boston Edison, while appreciating the metal clad features of State Line Station, thought that a low price form of structure or shell over the switches thereby making possible a less expensive switch design would provide an alternative arrangement and perhaps a serious competitor to the metal clad type of switch structure.

In discussing the metal clad switch gear at State Line, one of the Westinghouse representatives pointed out that metal built gear (he preferred the term metal built in preference to metal clad) is not a piece of apparatus but that it is an assembly of a number of independent components and it was to that fact that he attributed the great success of metal clad switch gear. These assemblies were shipped complete ready to use from the factory and incorporated all the advantages of precision factory workmanship.

Mr. Hall of the United Co. stated that these papers proved to him that modern switching equipment was far from being standardized, that it was very much in a state of flux. The trend, he thought, was away from the isolated phase arrangement and toward some form of metal clad gear.

An interesting feature of this symposium was the fact that at one of the switching stations air break circuit breakers had been installed.[1] In commenting upon this fact Mr. Hall pointed out that in the past we have all been oil conscious and while oil circuit breakers had proved reasonably reliable, as long as we had oil circuit breakers we would have trouble from oil leaks and the consequent danger of fire. In pointing out this danger, he cited one case where a fast moving piece of casting thrown out from an exploded breaker punctured the radiators of an adjacent transformer which started a disastrous fire. This danger he said might be eliminated by the use of non-inflammable oils but the deion type of breaker it seemed was a better alternative. Mr. Hall also discussed the question of very large generators. He was of the opinion that in most cases smaller generators would meet requirements much better and could be made just as economically. Their experience at Hell Gate with the first two 160,000-kw. generators convinced them that no system at present is large enough to justify generators larger than 80,000 to 100,000 kw.

Philip Sporn of the American Gas & Electric Co. disagreed with Mr. Hollister of Sargent & Lundy on the question of generator voltages. He did not believe that the tendency for voltages to go upward was true and cited several cases in his own station where originally it had been the plan to use higher voltages but when the problem was analyzed invariably it

[1] Essex Station at Connors Creek, Detroit Edison Co.

could be shown that a lower voltage was more economical.

In referring to the conditions that existed at Long Beach where the author of the paper had found it quite possible to synchronize on 220 kv., Sporn pointed out that this is nothing new but that they had been doing that very thing on 132 kv. since 1925 on the lines of the American Gas and Electric Co.

Speaking for the manufacturers, R. H. Summerhayes of the General Electric Co., took exception to Mr. Hollister's statements that the manufacturers are behind in the matter of circuit breaker design. He insisted that they were far ahead and pointed to the fact that they could build breakers which would reclose before the arc which had caused it to open had actually been extinguished. Naturally, he said, no one would want a breaker to operate so rapidly.

H. W. Eales of Byllesby found it deplorable that the latest and newest station was out of date before it was completed. He cited several instances which showed how rapidly switching equipment became obsolete. The first station he said he was associated with was the sub-station receiving power at St. Louis from the Keokuk station. This station was the most modern station in 1913, yet four years ago it was torn down, all the existing equipment scrapped and completely rebuilt. Everything in it, transformers, circuit breakers, disconnects, etc. were all obsolete. Referring to State Line, he pointed out that the labor situation in Chicago was probably a factor leading to the use of the metal clad gear at State Line. This gear was all completely manufactured and assembled at the factory and therefore required a minimum of field labor. Mr. Eales brought out another important factor in the design of any switching system and that was that any isolating device must be physically separated from the apparatus it is supposed to isolate. This factor he said he had always kept in mind when designing his own stations.

Demonstration of Auditory Perspective

Perhaps the most interesting event of the entire meeting was the demonstration of the auditory perspective system of electrical sound reproduction on Wednesday night, January 24. The history behind this development went back to April 27, 1933, when another milestone in the development of the communication art was passed and the music of the Philadelphia Symphony Orchestra was picked up in the Academy of Science Hall in Philadelphia and reproduced in Constitution Hall in Washington with a fidelity, depth and special effect that actually created the illusion of the orchestra's presence behind the stage curtain. As a preparation for this demonstration there had been a symposium on the subject in the afternoon. At this symposium five papers were presented, one on each separate phase of the system. These five papers were preceded by a short introduction by Harvey Fletcher in which he outlined the basic requirements of the system. All the work was done by members of the Bell Telephone Laboratories who presented these papers.

The demonstration of auditory perspective was preceded by the presentation of the Edison Medal to Dr. Arthur E. Kennelly for meritorious achievements in the electrical field.

Thursday, the last day of the convention proper, was devoted to four sections, two on the subject of electrical machinery, one on power distribution, and one on electrical measurements. The session on power distribution included four papers, one describing the suburban distribution system of the Edison Electrical Illuminating Co. of Boston, one discussing radio versus primary network distribution, by H. E. Wulfing, of the Commonwealth Edison Co., one on the fundamentals of design of electrical energy delivery systems, outlining the practice of the Buffalo-Niagara and Eastern Power Co., and finally, one on the joint use of poles with 6900-v. lines. This last paper was presented by W. R. Bullard of the Electric Bond & Share Co. and D. H. Keyes of the American Telephone & Telegraph Co.

At first the discussion of these papers partook of a controversial nature regarding the respective merits of the radial and the primary network distribution systems. The proponents of each system advanced arguments showing why each of these systems had advantages over the other. D. K. Blake, however, pointed out that it was not so much a matter of which system was the best but rather which system was the best for a particular set of circumstances. He said it was not necessarily a case of a radial system being better for Chicago and a primary network system being better for Boston but which of these two systems was the best for a particular locality either in Boston or Chicago. He said there were cities in which all of these systems were applicable; and that it was unnecessary to put these systems against each other as being exclusive.

The session on electrical machinery involved the presentation of three papers, one on an experimental ignitron rectifier, one on inductor alternators for signalling purposes, and finally a paper on induction motors as selsyn drives. The paper on the experimental ignitron rectifier was perhaps the most interesting of this series. The rectifier built in these experiments aimed at the elimination of the tendency to backfire and from the results which the author cited this object had been attained. The ignitron rectifier is a special rectifier using an auxilary electrode to initiate the discharge in place of the usual grid in the ordinary mercury vapor rectifier.

Among other things the authors described the construction of a polyphase ignitron built for a test in a six-phase or double three-phase circuit. The arc drop in this rectifier was slightly more than nine volts. At the time that the paper was written this ignitron had operated for more than forty-nine hours in a six-phase circuit supplying 300 amp. at 300 volts d.c. or 90 kw. to a rotating machine load. During this time no backfires occurred nor was there any other indication that the unit had reached its maximum capacity.

Friday, the last day of the Convention, was devoted entirely to inspection trips. The most important of these was a special all day motor bus trip over a route covering a large area in the northern part of the state of New Jersey, stopping for inspection of the Commercial Long Wave and Short Wave Radio Communication Stations of the RCA Communications, Inc., and the American Telephone & Telegraph Co.

The Convention was well attended, the total registration was 1227.

POWER PLANT ENGINEERING March 1934

Electric Pressure Brazing *of* Cable Terminals

By
JOSEPH A. KENDRICK
Safe Harbor Water Power Corp.

UNDER THE AUSPICES OF the General Electric Company the author was instrumental in developing appropriate appliances for brazing in accordance with the basic inventions of D. Basch and M. Hennessey, by means of which terminals may be attached to cables without the use of solder or any fluxing agent whatever. It is only necessary that the cable if solid, be tinned, and if stranded that the strands be tinned. In the event that the cable strands are not tinned, a few layers of sheet solder inserted among the strands will suffice.

This sheet solder should have a composition of 90 per cent lead and 10 per cent tin. It may be of interest to note that excess tin when melted in the immediate vicinity of highly heated copper may cause destructive embrittlement of the copper.

Mechanical Pressure Used

This method of joining cables is called Electric Pressure Brazing, so named because electrical current, accompanied by considerable mechanical pressure is employed. It should be carefully distinguished from ordinary brazing, as it is commonly known, and from electric welding.

Electric Pressure Brazing as distinct from soldering, ordinary brazing, or electric welding is accomplished by passing sufficient electric current through the cable end and the terminal thimble to bring them to a plastic (not molten) state while simultaneously being subjected to mechanical pressure. The amount of current and the intensity of the pressure required depends upon the cross-sectional area of the cable and terminal which are to be united. Experience has shown that 800 amp. is a minimum for even the smallest work. The pressure ranges from 30 lb. upward.

The accompanying illustration shows a more or less inexpensive electric pressure brazing bench outfit which is easily constructed and by means of which terminals can be brazed to cables up to 1,000,000 c.m. In fact all of the experimental work performed by the author and his associates was accomplished with this outfit.

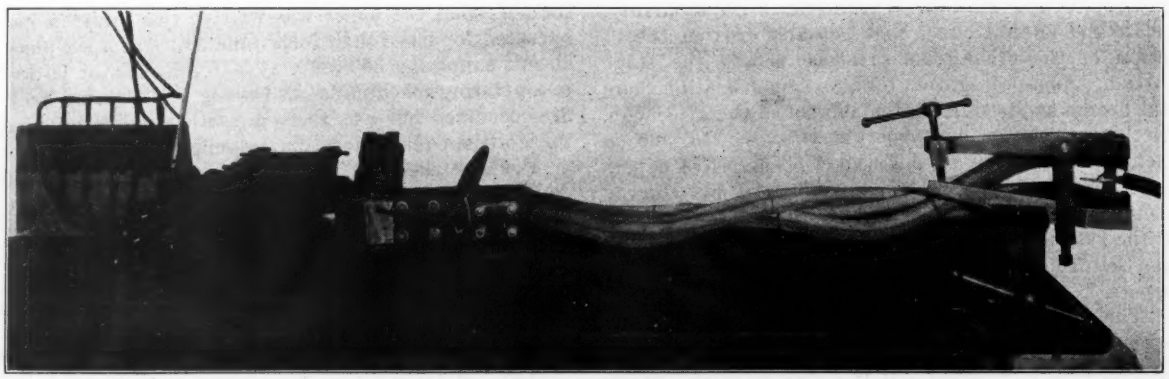
As shown the outfit consists of a safety switch, a contactor, a 10-kw. welding transformer with three pairs of primary taps for 220 v. circuit, a secondary winding made up of one turn, that is a U shaped bundle of laminated copper sheets, the ends of which are connected ot six 800,000 c.m. flexible strand, extra flexible strand is better, asbestos covered cables (three cables in each side of the circuit). These cables are about 6 ft. long. The opposite ends of the cables, it will be noted, are fastened to opposing jaws of a screw clamp which is held by the bench vise. Between these jaws two suitable steel dies grip the cable and terminal which are to be brazed. The contactor is energized through a foot switch resting on the floor at the feet of the operator. The primary taps of the transformer are arranged to deliver one, five or ten thousand amperes in the secondary circuit.

The cables in the secondary circuit should be twisted about each other in order that the mutual inductance will be neutralized as much as possible. This is especially desirable when 10,000 amp. are required. Lower ampere values may be obtained by merely untwisting the cables. Hence with the multiple primary taps and the effect of twisting and untwisting the cables, almost any desired ampere values may be obtained.

The ends of the secondary cables are cast into copper terminal blocks which are machined and drilled for bolting. One side of the secondary circuit is insulated from the screw clamp jaws. A piece of sheet asbestos is used for this purpose as it is resistive to heat and affords ample insulating value for the low secondary voltage.

Dies Are Important

Welding transformers with multiple taps and of the kind shown may be procured from electrical manufacturers. An open window or windows will be left for the secondary one turn winding.



AN INEXPENSIVE ELECTRIC PRESSURE BRAZING APPARATUS

The dies are shaped to conform to the terminal and are provided with a base through which holes are drilled for clamping screws. Cyclop Steel is used in the manufacture of these dies. It is necessary, of course, to use a steel which has considerable compression strength at high temperatures.

When brazing a terminal to a cable the insulation is removed in the usual way and the terminal put in place. The whole is then gripped lightly between the dies as shown. The current is then turned on and held until the terminal is heated to a bright red color. The current is then cut off and the dies rapidly compressed by means of the screw clamp. In fact the screw clamp should be slowly actuated, that is tightened, during the time that the current is flowing. A little practice, however, will enable the operator to determine the best procedure. The yield of the metal can be readily felt at the screw handle which is a signal to cut off the current, compress the dies rapidly and to the fullest extent. In order to prevent any possibility of injury to the cable insulation from burning due to its close proximity to the heated terminal, a wet cloth may be wrapped about the cable at this point.

May Be Made Portable

While the outfit herein described and illustrated is a bench device, it could also be very readily mounted on a small truck, and moved about a plant or construction job wherever terminal brazing was required.

Possibly it may be desirable to use this method in place of soldering only in those cases where cables are subjected to abnormal conditions such as heavy and long continued overloads or when cables are connected to heating devices, grid resistors, etc.

For these abnormal conditions the Pressure Brazing method is especially adaptable. Terminals brazed to cables in this way literally combine or unite to form an integral piece. Not only does the cable and terminal become an integral unit, but the individual strands of the cable are compacted and brazed to each other to the extent that these individual strands are no longer discernible to the unaided eye. In fact the brazed portion of the stranded cable may be machined and threaded as in a solid rod or bar.

Joint Resistance Low

It is obvious that this method is distinctly superior to that of soldering.

The joints have a high electrical conductivity, practically equal to that of the solid conductor. They also have a permanently low resistance. This low resistance is due in a large measure to the fact that the cable strands and the terminal walls have been forced together under high pressure and retained so. In this connection it should be remembered that the current carrying capacity of a joint is a function of the contact pressure.

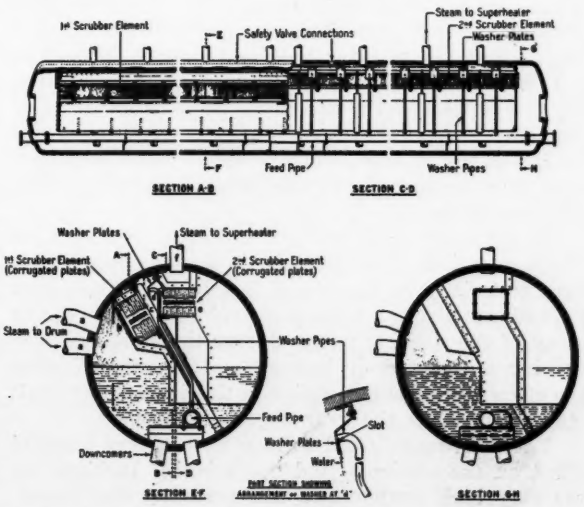
In the preparation of this article the author is indebted to the General Electric Company for the use of the accompanying cut. He also wishes to give due credit to D. Basch and M. Hennessey of the General Electric Company for their very loyal support in the performance of the experimental work.

Reducing Boiler Carryover

DETAILS of the boiler drum baffling and steam scrubber installed at South Amboy station are shown by the accompanying drawing. This scrubber replaced baffling which was allowing a carryover of only 8 to 10 p.p.m. This is ordinarily considered good operation so that the efficiency of the new scrubber which brought the solid content of the steam down to 0.2 p.p.m. can hardly be questioned.

The scrubber is designed to remove all possible moisture from the steam and then remove the solid content from the remaining moisture. The first section or scrubber is a corrugated plate separator from which the separated moisture is returned to the drum. The steam and remaining moisture then pass through the water spray shown by Section d. This spray is incoming feedwater, practically pure. The comparatively dry steam passing the spray picks up pure water which dilutes the boiler water remaining in the steam before passing the second scrubber. Moisture remaining after this section enters the dry pipe but the moisture approaches the solid content of the pure feedwater because of the dilution process.

During tests boiler concentrations were built up from the normal 100 p.p.m. to as high as 2350 p.p.m., and, with the water 2½ in. above the center line of the water column, the solid content of the steam was 0.20 p.p.m. With a concentration of 1900 p.p.m. and the water level 4 in. above the center line of the column the solid content was less than 0.30 p.p.m. At concentrations up to 500 p.p.m. it was possible to maintain the water as high as 7½ in. above the center line with no increase in solids. Normal operation now runs around 300 to 400 p.p.m. in the boiler water and the solids in the steam run consistently from 0.2 to 0.3 p.p.m. with considerable periods as low as 0.14 to 0.17 p.p.m. Boiler water pH is maintained at 10.8 but after passing through the separators the steam condensate is practically neutral. After the change it was necessary to start feedwater treatment at the hotwell in order to protect the piping, heaters and pumps from corrosion.



DETAILS OF THE SOUTH AMBOY SCRUBBERS WHERE THE STEAM IS WASHED WITH FEEDWATER

POWER PLANT ENGINEERING March 1934

Turning Gears *for* *Steam Turbines*

By Guy Bartlett*

IN A MODERN power station in the usual case, depending on the unit or station efficiency and the estimated load, a definite amount of generator capacity is promised to be on the line, ready for load, at a definite time. It is, therefore, necessary for the station operator to put the auxiliaries into service and to start the units revolving slowly, a definite time ahead of the time promised. The time taken to bring a turbine up to full speed is called the starting period and is calculated to allow the shaft and casing to become evenly heated and straight, to see that the lubrication system is functioning properly, and to see that the unit is in all respects ready for load. It also allows time for checking over the operation of the boiler and plant auxiliaries.

The starting period is affected by several factors, most important of which is the straightness of the turbine shaft. Due to internal vapor circulation, the shaft usually starts to bend quickly after it comes to rest, particularly if for some reason a steam seal has not been shut off, or if water is left running on the water packing. A leaking throttle valve is a common source of this trouble.

Turning gears remove the uncertainty of the starting period and obviate the possibility of a prolonged starting period that would be required were the shaft bowed due to uneven heating. These motor-driven gears keep the rotor revolving at a relatively low speed during the whole period of shut-down, whenever it is anticipated the machine will be required for service within a few hours or a few days. The idea was that as a revolving shaft would not become bent, there would be no necessity for a long period of slow speed to straighten it out. Turning gears have been successful in keeping shafts straight and have had quite wide acceptance.

It has come to be realized, however, that turbines which give little or no difficulty in starting may benefit very materially by the use of this device. There may be and usually has been some rubbing and wearing away of the packing points during the starting cycle, causing an increase in leakage and directly affecting the efficiency. The prevention of this increase by itself may easily make the gear a good investment.

The bending referred to may have a very harmful effect on the efficiency and operation of turbines for the very high temperature and pressure now considered practical, and turning gears are much more important for these units. Without a turning gear and because of the rather high resistance to rotation of the rotor in the bearings, it is usually necessary to open the main steam valve enough to allow a very heavy rush of steam at starting. The starting resistance is high for about half a revolution because most of the oil is squeezed out from underneath the journals during the standing period. The heavy rush of steam is not desirable because the turbine parts heat too quickly, and for other reasons. If a turbine is being slowly rotated by a turning gear, the flow of steam can be admitted very gradually. The high steam temperature now being adopted will make this feature more important.

TURNING GEAR MOUNTED ON THE BEARING CAP OF A 35,000 KW. TURBINE

Use of a turning gear permits steam to be applied on packings during the period when vacuum is being brought up, thus considerably reducing the time necessary for this operation.

The gear is useful for jacking the shaft through small angles during inspections, both the thorough periodical inspection and for the ordinary inspection of the various elements of the complete unit, including the generator and exciter.

In order to avoid the necessity of auxiliary apparatus, the gear should be made sufficiently strong to start the turbine from rest with the bearings hot, as would be the case directly after a shutdown. This is the most difficult starting condition. It requires an effort many times greater than that necessary to keep it revolving with the bearings cool. Rather than run the regular steam driven auxiliary oil pump, it is usually found desirable to supply a small low-pressure motor driven pump capable of supplying oil to the bearings and turning gear for lubrication. The pressure needs to be only enough to assure that some oil flows into the bearings, perhaps 2 or 3 lb. per sq. in. It has been found that one or two revolutions per minute will keep the shaft perfectly straight and permit starting without packing rubs. Power requirements are low. A 5-horsepower motor is sufficient to start a 30,000-kw. rotor from rest, but a small fraction of that power will be required to keep it in rotation.

*General Electric Co., Schenectady, N. Y.

Details of the *COUNTRY'S LARGEST DIESELS* at Vernon

Five 7000 Hp. Diesels in California Municipal Plant Set New Record for Diesel Stations

NEW STANDARDS of Diesel power stations have been set by the 35,000-kw. municipal Diesel plant at Vernon, Cal. The five engines built by The Hooven, Owens, Rentschler Co. of Hamilton, O., have eight 24 by 36 in., double acting, two cycle, solid injection cylinders and are rated at 6850 (nominally 7000) b.hp. at 167 r.p.m. They each drive a direct connected Allis Chalmers 5000-kw., 7200 v., 3 ph., 60 cycle generator. Shop tests are reported to show a fuel consumption at full load of less than 0.38 lb. per net b.hp. hr. The fuel curve is flat so that at ½ and ¾ load the fuel economy is close to the full load value.

Engines are of the well known MAN design and a number of the features are of unusual interest, especially to American readers. One of these is the extremely low weight of about 90 lb. per b.hp. made possible by the careful design, metal distribution and erection. The frame consists of a reinforced cast-iron bedplate (B of Fig. 2C), cast in two sections because of the unusual length of the eight cylinder engine. To this bedplate are bolted A frame housings (A of Fig. 2C) between which are bolted oil cooled crosshead guides (C of Fig. 2B) to give the necessary longitudinal rigidity. Cylinders, cast separate, are bolted together on top of the housings.

Construction is such that the cast-iron parts are subjected to compression only. The power load from combustion is taken from the cylinder heads to the 4 in. tie bolts (D of Fig. 2C) which run from the top of the cylinder to the bottom of the bedplate. There are four of these bolts per cylinder, each bolt stressed to 120,000 lb. This insures the cast-iron frame being always in compression even during the maximum upward stress of 270,000 lb.

Various parts of the frame, fitted and scraped, are put together with metal to metal joints. In order to insure rigidity and ease of assembly, the parts are put together with reamed bolts, each joint being fitted until a 0.001 in. feeler could not be worked in the joint. Crank case, totally enclosed, is supplied with oil from a rotary pump attached to the forward end of the shaft. The top cover and dividing plate has a stuffing box with three scraper rings to prevent the loss of oil upward along the piston rod as shown by section Fig. 2B.

Cylinder, liner and head constructions are shown by Fig. 2. Cylinder heads are made in two parts with cast steel for the parts subjected to high temperatures and a cover of cast iron as shown by Fig. 2B. The upper head has one fuel valve in the center and one relief valve. The lower heads have two fuel valves, a relief valve and air starting valve. Fuel valve nozzles are so located that fuel is not sprayed on the piston rod but, as an added protection, a KA2 steel sleeve, E of Fig. 2B, is used. With the piston in the lower position, the rod is completely covered. The Cooke cast-iron packing used in the lower cylinder head is lubricated at two points. Cylinder heads are held together by throughbolts (G Fig. 2B) running the full length of the cylinder.

Liners are made in two parts, the top section carrying scavenging and exhaust ports for both ends of the cylinder. The lower or short section joins the upper at the wavy junction line, F, of Section 2B. The lower cylinder head and lower liner are removed from the bottom, after pulling the piston, by means of a dolly and special frame which runs in under the cylinder.

Only the hot ends of the liners are water cooled. Cooling water enters the lower head at H, Fig. 2B, and by means of baffles is given a positive direction around and up the length of the cylinder in a spiral passage. Cross sections of these passages have been varied to give higher velocities and consequently higher heat transfers in the hottest parts of the cylinders. From the lower head the water passes up through the elbow J to the lower liner jacket up through the top liner jacket and out through the top head at about I, Fig. 2B. Positive direction of the water and velocity control is intended to give an even metal temperature throughout the length of the cylinder.

Scavenging air from Allis-Chalmers 2900 r.p.m., 32,000 c.f.m., 2 lb. motor driven blower enters the cylinder from the manifold (C, Fig. 2B) through the inner ports. As a result of carefully designed entrance angles and piston contour this air makes a complete circuit of the cylinder and leaves by ports L Fig. 2B. Here the gasses guided by baffles (M Fig.

FIG. 1. INDICATOR CARDS TAKEN WITH A 700 LB. SPRING (REDUCED TO HALF SIZE)

2B) leave the engine without shock, eddy or noise, guided in the proper direction. Contrary to usual practice, the manifolds are made of cast iron whose added weight prevents the panting noise so common with sheet iron manifolds. They are not watercooled but are covered with asbestos.

Pistons are built up of a forged head and cast steel body arranged for circulation of water between the two parts. This water reaches the piston through telescopic piping and the bored piston rod. Passages in the piston rods are chromium plated to prevent corrosion and all fillings and ports in the piston are made of stainless steel rather than brass in order to eliminate electrolysis. A special air chamber or trap preceding the telescopic slides prevents water hammer or knocks even when discharging into a closed system under different pressures.

Like the bedplate, the 16 in. forged shaft is made in two sections. To the center section of the shaft is geared the layshaft driving the two eight plunger fuel pumps. Fuel injection cams are shaped to simulate the long fuel injection period of the air injection engines and the offset indicator card of Fig. 1 shows how closely the ideal has been approached. Fuel flow is controlled by a bypass in the discharge actuated through an eccentric cam and servomotor by a flyball governor. Fuel valves are water cooled to the extreme tip to prevent plugging and carbonization of the nozzles.

Because of the close regulation necessary, 2 r.p.m., added precautions have been taken to eliminate air pockets in the oil piping so that the necessary amount of fuel will be delivered each stroke. Oil flows by gravity to a constant level tank and then by a bottom discharge to the 0.003 and 0.004 in. strainers before flowing to the suction of the fuel plunger. A vent line from the top of the strainers takes any air back to the tank. Even under full load about 2/3 of the oil delivered by the plungers is bypassed. This bypassed fuel is collected in a manifold and returned to the top of the strainers.

An overspeed governor shuts down the engine at 175 r.p.m. and must be set by hand before the engine can be started again. The engine is started by 350 lb. air (reduced from 1000 lb. bottles) by automatic air starting valves. When the starting lever is placed in the start position air pressure is admitted to the starting valves. This air pressure is just about sufficient to counter balance the spring loaded valve so that when air from the starting cam is admitted behind the pilot valve the main valve opens and admits air to the lower side of the piston. Air valves close automatically when the pressure is removed from behind the pilot valve or when the pressure in the cylinder exceeds that of the starting air. There is no possibility of this valve remaining open during a firing period.

Each cylnder is lubricated by a 12 pt. Hills-McCanna forced feed lubricator. Six points are symmetrically spaced near the top of the head end and connected by an oil groove cut in the liner. On the lower side, four points are spaced around the cylinder and two go to the stuffing box. Two Brown eight point pyrometers are installed on each engine to give the exhaust temperature from each end of each cylinder.

Both performance and appearance of the engines are unusual, not the least important feature in the design being the convenience and accessibility of parts and walkways for operation and maintenance. The thermal efficiency of 37 per cent and the mechanical efficiency of 90 per cent testify to the excellent performance. It is said that from detailed estimates based on prevailing prices of fuel oil and a capacity factor of 50 to 60 per cent, engines of such fuel economy should produce power for less than 5 mills per net kilowatt hour, including all operating and fixed charges.

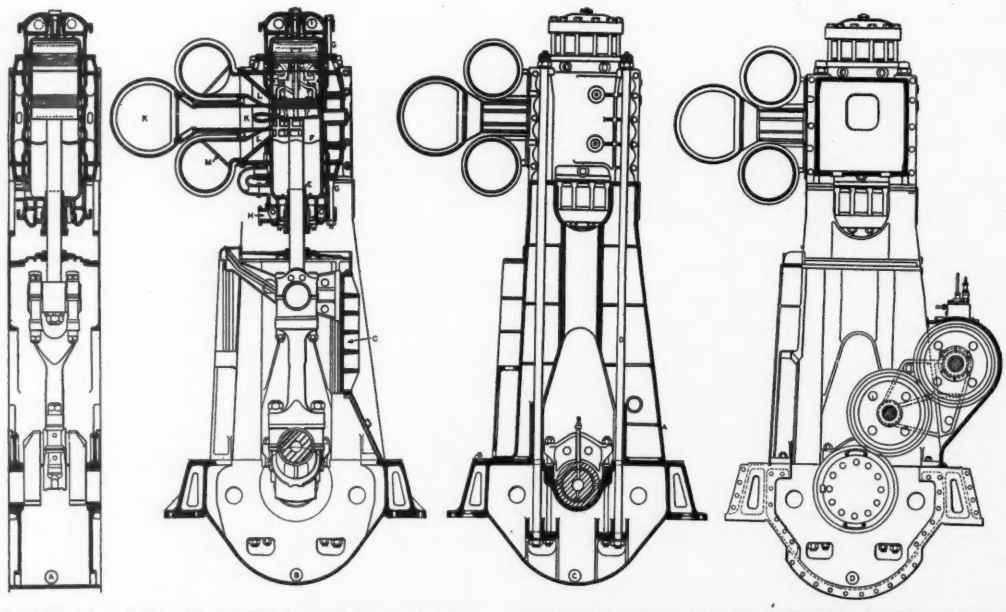


FIG. 2. GENERAL ARRANGEMENT OF THE ENGINE, A, LONGITUDINAL SECTION THROUGH CYLINDER, B, CROSS SECTION THROUGH CYLINDER, C, CROSS SECTION BETWEEN CYLINDER, D, END ELEVATION SHOWING LAYSHAFT AND GEAR ARRANGEMENT

Air Conditioning *at* Rockefeller Center

Three Hundred Ton Steam Jet Refrigeration System of the Maison Francaise Sets New Standard for Office Building Air Conditioning

By Andre Merle*

ROCKEFELLER CENTER, the new $250,000,000 building development known as "America's Most Modern Building Project" is located in the mid-town section of New York City. Aside from its sheer size and architectural splendor, it houses mechanical equipment representing the most advanced engineering design. Some of its salient mechanical features have never previously been accomplished. High speed automatic elevators, escalators, automatic heating, scientific lighting, steam refrigeration, modern, silent plumbing and scientific air conditioning, with sound elimination if desired by those who may be decibel conscious. These important, modern features and devices were incorporated so as to fulfill the demands of our present era.

To better visualize and acquaint one's self with this much talked of project, let us picture a development which upon completion will have installed not less than 10,000 t. of refrigeration, fans, dehumidifiers, controls and galvanized iron ducts to distribute over 240,000,000 cu. ft. of completely conditioned air every hour and pumps which will circulate over 2,600,000 gal. of refrigerated water per hour. These quantities represent but in part the "Air Conditioning" requirements but incidentally, they surpass both in size and originality of assembly all previous conditioning installations. By means of this equipment one can practically manufacture climate, controlling and varying its temperature, adjusting its moisture content or humidity, heating and humidifying during the winter season, cooling and dehumidifying during the summer and distributing our machine made climate as required.

Countless installations in the office buildings indicate that from $0.20 to $0.25 per sq. ft. per yr. (say 2 ct. per mo.) will cover the complete cost of installation, operation and depreciation of a modern air conditioning system. The installation of a conditioning system represents the greatest single improvement that building owners can make. One need but visit an air conditioned theater, office building, store or restaurant and experience the delightful and invigorating indoor climatic conditions to be convinced of this fact.

Let us now confine ourselves to a word picture of the air conditioning system installed at the Maison Francaise, a structure dedicated to the interests of French trade and international good will, flying the tri-color and standard of both France and the United States. The building architectural decorations are also in French style. It occupies the northwest corner of Fifth Avenue and 49th Street, and is six stories in height, extending approximately 85 ft. above street level. Below grade is a basement and sub-basement. Frontage on Fifth Avenue is 70 ft. and on 49th Street is 200 ft., a ground area of 14,000 sq. ft. The street level and first basement will house high grade shops or stores and a typical Parisian restaurant. The second to sixth floors, inclusive, have been assigned for office and display uses. The exterior finish of the building is granite and limestone, and the roof area will be landscaped with trees, shrubbery and flowers. The total conditioned area is in the neighborhood of 85,000 sq. ft. and a volume of well over 1,100,000 cu. ft.

All of the air conditioning equipment such as fans, dehumidifiers, control panels and the 300 t. steam jet refrigeration equipment are installed in a space 40 ft. deep, 70 ft. wide and 14 ft. high, an area of 2800 sq. ft. Of special importance is the fact that the floor space requirements for the steam equipment is well within that required for standard refrigerating apparatus. Incidentally, the operating weight is approximately 40 per cent less than the more conventional systems employed heretofore.

The steam jet refrigeration system in the Maison Francaise is one of the first and largest ever installed for complete air conditioning although steam jet refrigeration has long been utilized for chilling water in the industrial processing field. The completed steam unit consists of two large steel, cylindrical tanks known as the cooler and condenser, steam jets or boosters and the connecting steam and water piping. All of the equipment is standard, long used and known to the steam engineering field. Steam jet refrigeration, therefore, is not a spectacular or experimental process, but rather a long established and reliable one.

As a safety measure a thermostat located in the flash tank will automatically close the main steam valve should the chilled water temperature approach the freezing point. The flash tank is approximately 7 ft. in dia. and 18 ft. long constructed of welded structural plates. During normal operation, less than 4 per cent of the total chilled water circulated will be evaporated. This water is condensed along with the ejector steam and removed by the condensate pump. Cooling towers were installed as a measure of economy and water conservation. A series of tests fixed the condenser water requirements at 5 gal. per t. with a cooling range of 20 deg. F. This is well within the

*Air Conditioning Engineer, Staff of Clyde R. Place, Consulting Engineer.

performance range of spray type induced or forced draft cooling towers. Make-up water is furnished automatically by a pump located in the sub-basement and also the roof house tank. The completed cooling tower measures 20 by 19 by 22 ft. high and is housed entirely within the pent-house or roof level of the building. The tower is constructed of California red fir with the water pan lined with sheet lead. Four double stage, disc type fans are installed on the top of the tower. In order to insure freedom from mists of water spray, extra depth eliminators were installed. Should an emergency arise, city water can be utilized direct until the towers or pumps are placed in operation. The total operating weight of the tower is 134,000 lb.

Three Air Conditioning Distribution Systems

To better control the conditioning of the building and maintain it economically, three separate conditioning zones were established: Basement floor zone; ground floor zone; second to sixth floors zone. Each zone has an independent air conditioning apparatus. This arrangement permits the operation of any zone or part of a zone. The routing of the galvanized iron duct work was greatly simplified and the various pieces of mechanical equipment were of a size easily handled. The installation of but one zone or system would have called for special structural conditions.

A decidedly unique and novel system of air distribution consisting of window cabinets is installed throughout the office section under each window. The basis of the system is the noiseless introduction of relatively small quantities of cool conditioned air at a velocity of from 1400 to 1500 ft. per min. Active, uniform air circulation is created ejector fashion and from two to three times the original quantity of ejected air is circulated. The pick-up air tempers the entering dehumidified air and there is not the slightest indication of a draft throughout the entire building. Individual control of these cabinets is readily accomplished by the turning of a small knob until the conditions desired are obtained. The dehumidified air is supplied to the window cabinets through vertical ducts located in the outer walls extending from the first to sixth floors, inclusive.

A central corridor acts as a plenum and allows the exhaust or return air to be conveyed to the exhaust shaft or flue. Considerable saving in floor space and head room results. The exhaust or return air duct located in the elevator corridor is the only duct within the office space. Valuable floor space is, therefore, not utilized for ducts and a pleasing architectural treatment produced. The system of air distribution for the stores consists of a high speed, double duty type air circulator. As this air enters the room it creates an active circulation of air within the conditioned space. The air is introduced through a specially designed combination supply outlet and grille located in the side wall over the show windows and as close to the ceiling as practicable. The conditioned air leaves the distribution grilles at a speed of 1800 ft. per min. It is interesting to note that less than 1 deg. F. difference exists at any point throughout a particular bay. The return ducts are located over the show windows adjacent to the supply ducts.

Arranged in this manner, the merchandise can be distributed at will without affecting the air distribution system. This arrangement provides for a maximum of comfort and presents an attractive and pleasing architectural treatment. An added convenience is the individual control of each room or store, by easily operated dampers, so air conditions can be adjusted to suit the desire of the occupants. This arrangement also enables the building manager to close temporarily the conditioned air outlets in unoccupied stores, resulting in economical operation. During the winter period the air is tempered by means of blast heaters located in the sub-basement. Between the outer wall and the window cabinets conventional direct concealed radiation is installed for normal winter heating.

Proper assembly, installation and operation of accurate, reliable temperature and humidity control and recording instruments is the first requisite of a successful air conditioning installation. A relatively new wet bulb type system designed by the writer has been installed. This system maintains a positive control of both the dry and wet bulb temperatures within the conditioned zone. It not only regulates the temperature and mixture of the dehumidified air, but through a system of primary and secondary thermostats, it controls both the rapidity and degree of temperature and humidity change. The control automatically admits the required amount of fresh air, insures the correct air pressure balance, excludes infiltration and provides a complete change of air conditions on the average cycle of 6 min. Instruments record the wet and dry bulb temperatures and also the chilled and condenser water temperatures. Gages indicate the various pump pressures and vacua at which the steam jet refrigeration equipment operates. The quantity of steam used and gallons of chilled water circulated are also recorded.

Automatic Temperature and Humidity Control

All of the air circulated throughout the entire conditioned area is chemically pure and fresh as it is thoroughly washed, filtered and ionized at all times. The airwashing feature consists of a new design combination dehumidifier, an air washer with three banks of sprays and one bank of flooding nozzles. The combination dehumidifiers were designed sufficiently large so as to produce comfortable air conditions by means of evaporative cooling. In order that the conditioned air be "alive" and "active" and absolutely free from any objectionable odors, it is thoroughly ionized. This is accomplished by means of three machines, which are connected to the various air conditioning systems.

John D. Rockefeller, Jr., as sponsor for the financing of this huge undertaking, formed the Metropolitan Square Corp. with Colonel Arthur Woods as president. The firms of Todd-Robertson-Todd Eng. Corp. and Todd & Brown, Inc., were selected as managers. The builders and general contractors of La Maison Francaise were Barr-Irons & Lane, Inc., while Baker-Smith, Inc., were the contractors who installed all of the mechanical and refrigeration equipment. The air conditioning apparatus was furnished by the American Blower Co. and steam jet refrigeration by Westinghouse E. & M. Co. All engineering, design, specifications and inspections were performed by Clyde R. Place and staff.

Sulzer Single Tube Steam Generator

Series Boiler Consists of a Single Tube 4270 Ft. Long Which Acts as Economizer, Boiler and Superheater

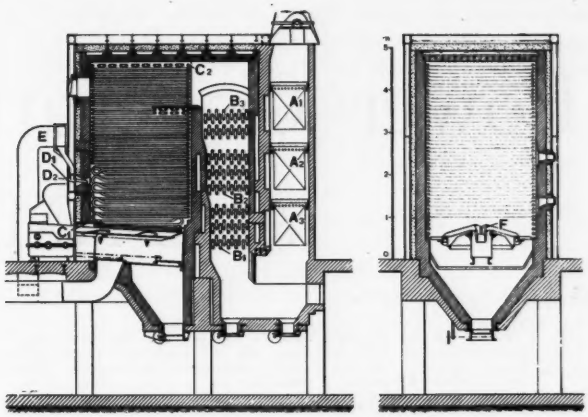


FIG. 1. A 1420 LB., 750 DEG. F., 16,500 LB. PER HR. BOILER AS INSTALLED IN A TEXTILE PLANT

A_1, A_2, A_3, low pressure economizer; B_1, high pressure inlet; B_2, B_3, high pressure economizer; C_1, inlet to combustion chamber; C_2, outlet from boiler; D_1, oil burners; E, forced draft duct.

TESTS on a Sulzer single tube steam generator installed in a Swiss textile plant were recently conducted by Professor Stodola of Zurich. This boiler, known in this country as the series type, consists of a single welded tube, 1300 m. (4270 ft.) long, varying between 30 and 50 mm. (about 1-3/16 to 2 in.) which acts as economizer, boiler and superheater. About 425 m. (1400 ft.) of the tube is in the combustion chamber shown by Fig. 1. The boiler with a total heating surface of 195 sq. m. (2100 sq. ft.) is built for a pressure of 100 atm. (1420 lb.), total temperature of 400 deg. C. (752 deg. F.) and rated at 7.5 t. (16,500 lb.) per hour of steam. It is fired by a single retort underfeed stoker and two auxiliary oil burners.

Regulation of the feedwater is accomplished automatically by means of two thermostats: one regulating the flow through the entire boiler, the other regulating the steam temperature by controlling the injection of water near the end of the tube. During the test plotted on Fig. 2, 5.31 t. (11,700 lb.) per hr. flowed through the entire tube and 1.97 t. (4350 lb.) per hr. was injected near the end of the tube giving a total steam production of 7.28 t. (16,050 lb.) per hr. at a total temperature of 370 deg. C. (698 deg. F.).

Pressure drop through the tube amounted to 30 atm. (425 lb. per sq. in.). The velocity was 1.5 m. (4.93 ft.) per sec. at the beginning of the tube, 3 to 18 m. (9.75 to 59.1 ft.) per sec. in the evaporating zone and 25.2 m. (82.8 ft.) per sec. at the superheater outlet. These high speeds, due primarily to the increase in volume of the steam and water, prevent steam bubbles clinging to the side of the tube and also tend to increase the heat transfer. Pressure is regulated by a hydraulic operated valve under control of the pressure. All regulation, including the combustion control, is automatic.

Pressure drop, p, steam temperature, t, heat transmission, Q, and velocity, W, are shown graphically in Fig. 2 as a function of the tube length. Pressure drops uniformly throughout the length of the tube while the heat transfer increases uniformly in each section, a sharp break, indicating a rapid increase in heat transfer, taking place at the entrance to the furnace section. Both temperature and velocity change materially at the entrance to the furnace and at the point of injection, some 220 m. (722 ft.) before the end of the tube.

Regulation tests were made by reducing manually the quantity of feedwater from 7.6 to 4.3 t. (16,750 to 9470 lb.) per hr. and by suddenly increasing the feed from 4.4 to 7 t. (9700 to 15,450 lb.) per hr., the superheat in the first case falling 19 deg. C. (34 deg. F.) and in the second raising 15 deg. C. (27 deg. F.). The two oil burners used as an auxiliary firing means were automatically cut out of, and into, service during these load changes.

The storage capacity of the single drum is about 760 kg. (1675 lb.) and tests were also made to determine whether there was a tendency for the tube to boil dry upon sudden increases in load. Accordingly, the steam flow was increased suddenly from 4.3 to 7.7 t. (9470 to 17,000 lb.) per hr. by opening a bypass, with a limited orifice, direct to the turbine condenser. The automatic control handled the condition satisfactorily, the pressure dropping suddenly from 98 to 90 atm. (1395 to 1280 lb. per sq. in.) and then coming back to the initial pressure in 1½ min. The temperature increased but 10 deg. C (18 deg. F.).

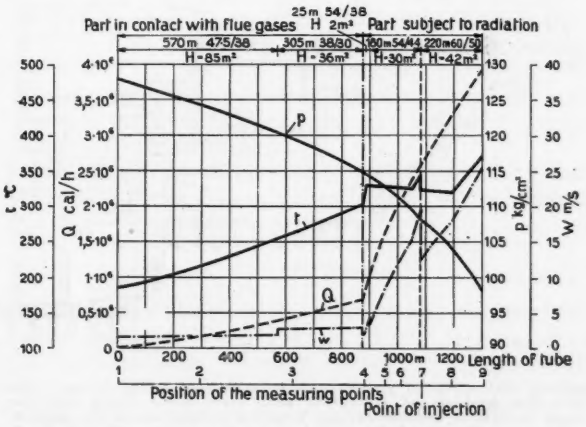


FIG. 2. PERFORMANCE OF THE UNIT UNDER TEST

t, temperature; Q, heat transfer; p, pressure; w, velocity. Deg. $F = 32 + \frac{9}{5}$ deg. C; 1 cal. = 3.968 B.t.u.; 1 kg. per sq. cm. = 14.22 lb. per sq. in.; 1 m = 3.281 ft.; 1 sq. m. = 10.76 sq. ft.

POWER PLANT ENGINEERING March 1934

Power Generation *on the* ALL-AMERICAN CANAL

AS PART of the Boulder Canyon Project Act, the Bureau of Reclamation is now building the All-American Canal with funds advanced by the P.W.A. Between the Imperial Valley the Colorado River lies a mesa and chain of sand dunes which extend across the border into Mexico. This made it necessary to build the original Imperial canal in a long bend curving southward into Mexico, thus complicating the control and limiting the area that could be brought under irrigation by gravity. Furthermore, conditions for diversion from the Colorado at the original Imperial Heading were not of the best.

The new canal will be higher with a new diversion dam about 25 mi. higher up on the river. This dam will be of the floating or Indian weir type with a crest 1700 ft. long. Six desilting basins are provided, any five of which can be used while the sixth is being sluiced. The river surface will be raised 22 ft. Capacity of the main canal is 15,000 sec. ft. from the dam to Siphon Drop where 2000 sec. ft. are diverted for the Yuma irrigation project. A small power plant operating under a head of about 10 ft. is already installed at this point and develops about 1000 kw. at a cost of about 0.8 ct. per kw-hr. Surplus power is sold and the net benefit of this plant amounts to about $54,000 a year. From Siphon Drop to Pilot Knob the canal capacity is 13,000 sec. ft. and the drop available for power from the diverted water is as shown by Fig. 2, from 50 to 60 ft. The capacity of the canal from this point on toward the Imperial Valley is 10,000 sec. ft.

After crossing the sand hills the canal divides, the Coachella Branch carrying 2000 sec. ft. going northward to Coachella Valley. On the Imperial Valley branch of the canal there are six drops varying from 7 to 48 ft. For the present these drops will be through concrete chutes. Later on power plants of the type and design shown by Fig. 1 will be added.

For 10½ mi. the canal passes through the sand hills, a region covered with dunes except for a few bare spots. The deepest cut in the sand-hill area is over 100 ft. and the dune sand is about 80 ft. in depth. Instead of lining the canal with concrete in this sand-hill area, it appears advisable to leave it unlined and prevent sand blowing into the canal as much as possible and to remove the sand by suction dredges if necessary. The canal section through the sand hills is designed with a mean velocity of 4.5 ft. per sec. at full capacity, which is intended to be nonscouring and nonsilting. Portions excavated in finer sand for the water section and liable to scour are to be over-excavated to a depth of 1½ ft. and the space refilled with screened gravel to form a scour-resisting lining. The following methods of preventing sand from being blown into the canal have been considered: (a) Growing vegetation on the sand in a zone on each side of the canal by irrigation from small pipe lines; (b) spraying the sand with crude oil; (c) covering the dune sand with material from the canal excavation in the mesa formation which is too coarse to be blown by the wind; (d) excavating a berm 15 ft. wide on each side of the canal at the mesa floor level. By adopting these methods in operation it is expected that the quantity of sand blown or drifted into the canal will be small.

From the sand hills the canal line runs west across the east mesa to the present east line canal of the Imperial district distribution system, and then through the extreme southern portion of the Imperial Valley, where it crosses 17 principal ditches and passes through the town of Calexico before it reaches the terminus the present West Side main canal. Here the water surface is —6.7, and at this point the canal has capacity sufficient to supply lands under the West Side canal and also to furnish water for additional lands on the west side mesa.

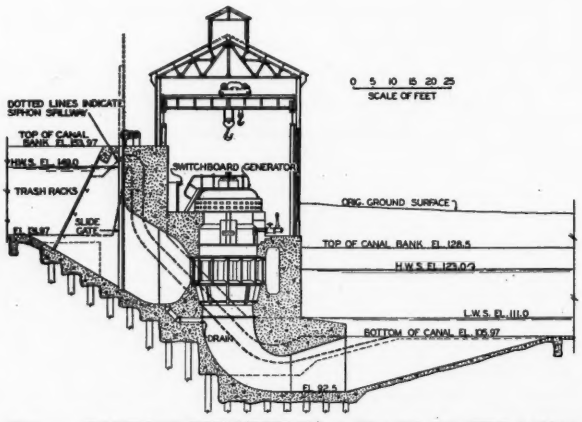


FIG. 1. SECTIONS THROUGH NO. 1 PLANT ON THE CANAL WHICH WILL CARRY WATER TO IMPERIAL VALLEY. NO. 2 PLANT DIFFERS ONLY IN WATER LEVELS

The Coachella branch canal will leave the All-American Canal about 16 mi. west of Pilot Knob and run in a northwesterly direction across the east mesa. The location crosses the Southern Pacific Railroad near Iris, passes east of the Salton Sea and the Coachella Valley to a point near the town of Coachella, where it again crosses the Southern Pacific and runs southwesterly across the valley, and then south to the Riverside-Canal line, ordinarily dry, but at times of heavy rains or cloudbursts, carrying floods of short duration, heavily loaded with sand and silt; these must be crossed with siphons or culverts. By combining these washes in groups by the use of training levees and diversion channels, the number of structures can be reduced to about 90. The last 47 mi. of the canal will be lined with concrete.

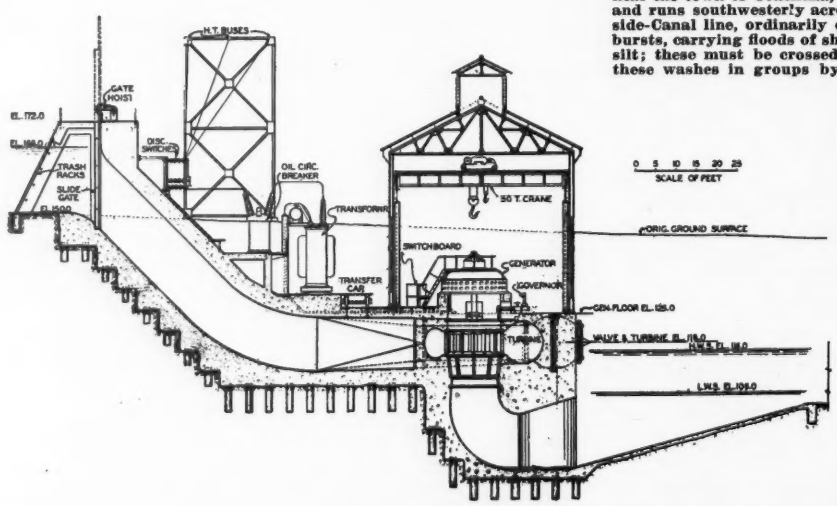


FIG. 2. PILOT KNOB PLANT WILL UTILIZE THE DROP OF 60 FT. WHERE WATER IS DIVERTED FROM THE NEW ALL-AMERICAN CANAL

The Imperial irrigation district, comprising 512,000 a., is supplied with a complete system of lateral ditches, with about 425,000 a. in cultivation. In the Coachella Valley about 16,300 a. are now under cultivation, being supplied by pumping from wells. There is no general canal or lateral system in the Coachella Valley. The east and west mesas, the Dos Palmas area east of the Salton Sea, Pilot Knob mesa, and the greater part of the Coachella Valley are desert lands with no improvements. It is contemplated that the boundaries of the Imperial irrigation district will be extended to include lands in the Coachella Valley irrigable from the canal when completed.

A Gallon *of* Coal

Figures May at Times Be Misleading. It Is Well to Consider All Factors Before Arriving at a Sometimes Costly Conclusion

By GEO. P. PEARCE

THE DOOR OF THE plant engineer's office suddenly opened and the superintendent accompanied by a stranger entered.

"Mr. Steelworth," said the superintendent. "I want you to meet Mr. Mayfield. Mr. Mayfield is an oil salesman and he says he can save us a lot of money by selling us a lighter grade of fuel oil which, although it costs more, will result in a saving to us on account of its higher heat content."

"I like to talk to engineers," announced the salesman smilingly as he shook hands. "They understand all about B.t.u's. and the concealed value of fuels and instantly see what a great advantage there is in my proposal."

"That's fine. If we can be of mutual advantage we certainly are going to do business," answered the engineer pulling up a couple of chairs. "Now just what is the proposition?" he queried.

"Mr. Maxwell has been showing me a sample of the oil you are now burning and I estimate it is somewhere between 12 and 14 Baumé; it's quite a heavy oil anyway and can't run much better than 18,500 B.t.u's. per lb. Now on account of the state of the market I'm going to offer you a far superior oil, an oil of about 38 Baumé which has 20,000 B.t.u's. per pound—just think of that, Mr. Steelworth—every pound that goes into the furnace takes an extra 1500 B.t.u's. in with it and there's a good many pounds in a gallon. And the slight increase in cost is nothing compared to the increase in heat you'll get, and, after all, it's the heat you are after."

"Yes, naturally, it's heat we are buying in fuel oil. What makes your oil have more heat than the kind we are now using?" asked the engineer with an innocent expression.

"It's the hydrogen content. We've got more hydrogen and less carbon in our product than the stuff you are using. It's nearer liquid hydrogen and further from soft coal Mr. Steelworth. Of course I don't need to tell an engineer that hydrogen has far more heat per pound than anything else known—it would be the ideal fuel if we could only handle it as a liquid."

"So you think your fuel oil, on account of it containing more hydrogen, would be a better fuel for us to use even if we had to pay more for it?"

"Precisely."

"But, Mr. Mayfield, we are having no trouble at all in burning the present oil and on account of our preheated air supply we are getting most satisfactory combustion," argued the engineer.

"The question of combustion isn't exactly the point I'm trying to make. We are offering you nearly 10 per cent more heat for only 6 per cent more money," explained the salesman tersely.

"You are doing nothing of the kind," retorted the engineer. "The oil you are offering, while it may have more B.t.u's. per lb., actually has less B.t.u's. per gal. on account of its lighter weight and, of course, it is by the gallon that we buy it. The heavy oil we are now burning has around 150,000 B.t.u's. per gallon whereas the oil you are suggesting barely has 140,000 B.t.u's. per gal. Before I could get interested in your proposal you would have to reduce your price considerably."

"B-But," stammered the salesman. "There must be some mistake somewhere; think of the hydrogen content!"

"There's nothing to this hydrogen talk so far as common oil furnaces are concerned. The more carbon we get for the same price per gallon the better off we are as long as we can properly burn it. Don't you realize that there is more heat in a gallon of soft coal—that you so contemptuously spoke of a moment ago—than there is in any oils; from the finest airplane gasoline all the way down."

"A gallon of soft coal? There isn't such a thing!" laughed the salesman.

"There's nothing impossible about that, is there? A soft coal of 14,000 B.t.u's. per lb. doesn't seem anything out of the ordinary, does it? And a soft coal of that heat value weighs about 84 lbs. per solid cubic foot. That is to say that for 1728 cu. in. of coal we get 1,175,000 B.t.u's. Now a gallon is 231 cu. in., which anyone can check up, and therefore 231 cu. in. of coal or rather a gallon of coal contains 157,000 B.t.u's. I have never heard of any oil as good as that and a gallon of your wonderful liquid hydrogen is only good for about 31,020 B.t.u's. Who can't talk about a gallon of coal?"

"Why don't you burn coal then?" snapped the salesman.

"Say if I could discover a way to make coal fluid I'd start rigging up to burn it tomorrow. Already some success is being obtained with a fuel oil enriched with powdered coal but the first man who can make coal flow through pipes and spray out of a nozzle will never have to worry about how much anything will cost before ordering it."

The superintendent pulled out his watch: "Well, Mr. Mayfield, we must be going. I think we've bothered Mr. Steelworth enough."

HEAT USED to raise the temperature, either of the water or stream is called sensible heat. If a pound of 32-deg. water open to atmosphere were slowly heated, its temperature would gradually rise to 212 deg. At this point, the temperature rise would stop but further addition of heat would cause boiling. As long as any water remained, the temperature would not rise but as soon as it was completely evaporated, the further addition of heat would cause the temperature to increase again and the steam would be superheated.

Readers' Conference

Eliminating Soot Blower Element Troubles

SOME TIME AGO several high pressure boilers were installed in a large industrial plant. Furnace temperatures were run at high values due to the exceptionally high ash fushion temperature of the coal.

After the plant had been in operation for a short time trouble was had with the lower soot blower tubes. These were found to be badly bowed from the high temperature to which they were exposed. After they were removed and straightened the same ones were tried again. Several months afterwards the same trouble again arose.

This time new tubes were installed hoping this would eliminate further trouble. A slight bowing still persisted and in order to prevent this a change in the method of blowing tubes was tried. The plant operated 24 hr. a day in three shifts. The morning shift was instructed to leave the soot blower element in a closed position. The afternoon shift was instructed to leave it about half way from closed to the opening point on completion of blowing tubes. The night shift left it in a position where it was just ready to open.

By this procedure all sides of the tube were exposed to the heat of the furnace for equal time intervals. Since this method has been employed no further trouble has been had from this source.

Waterville, Me. HARRY M. SPRING, JR.

Rearranging Electrical Facilities

FAMILIARITY with the layout of electrical equipment auxiliary to isolated plant service sometimes blinds the operating engineer to the possibilities of inexpensive rearrangements which will contribute to greater safety and convenience. When an operating man joins the staff of some public institution, for example, it is natural for him to accept the plant very much as he finds it. The architects and designing engineers have brought forth the facilities he is expected to run and maintain. For some time the engineer is busy getting acquainted with the details of equipment and its disposition about the premises, and often he hesitates to call attention even to minor betterments within easy reach until he feels solidly established.

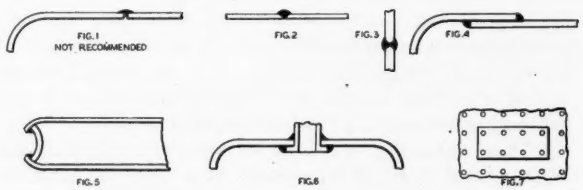
In due course, however, the engineer should make a critical study of his plant. If his employers are well worth working for, they will give proper consideration to his suggestion for betterment, particularly if these can be achieved at modest cost. Some of the changes desirable can often be effected in regular hours with little outside expense, and may not require the sanction of a board meeting to put through. Little things like the relocation of a tungar rectifier cabinet so that the metal cover cannot be opened against live knife switch blades are of this class; putting a small battery charging motor-generator set in more spacious quarters is another; replacing loosely run open cable in the switchboard room with carefully aligned and right-angled turn conductors is a third. Disposal of batteries for program clock service on symmetrically arranged shelves instead of in a broken-up assembly is a fourth. Better lighting is a field in itself which often is given little attention by the plant engineer, and this improvement can frequently be accomplished in part at least without heavy cost. Modernization programs are fine and necessary where funds can be had to carry them through; but long before appropriations for sizeable sums can be approved the engineer should have analyzed his plant from the angle of nominal cost improvements. By looking about him, he will find a surprising number of these to list unless his plant is exceptionally free from obsolescent practices and features which nobody thinks about because they are so much a part of the engineering landscape.

Cambridge, Mass. H. S. KNOWLTON.

Autogenous Welding of High Pressure Boilers

WHEN AUTOGENOUS welding processes came into general use some years ago, the ordinary mechanic who purchased an acetylene welding outfit began to deem himself competent to weld anything from a cast-iron stove lid to a high pressure steam boiler and would "guarantee?" the job at least long enough to collect his fee and get away.

Casualty insurance companies from the first viewed this method of construction and repair with suspicion. It is the function of insurance companies to be very conservative in regard to new and untried methods of engineering design. As time went on and accidents were reported of the failure of welded jobs, it became obvious that it would be desirable and preferable to regulate the activities of the welder in the interests of safety to the general public rather than to produce a few martyrs to the cause of engineering progress.



TYPES OF WELDS USED ON PRESSURE VESSELS

The ordinary layman in engineering gets too much of his information from people who are promoting or exploiting autogenous welding and ought also to be posted on the weak points of the process as well, and we think your readers will be interested in some of the ways such welding fails to fill the bill when applied to high pressure boilers, and pressure vessels. The new 1931 Code of the A.S.M.E. says no welding repairs shall be made before an inspection has been made by an authorized inspector and the method of repair

sanctioned by him. If, in the opinion of the inspector, a hydrostatic test is necessary such test shall be applied when the work is completed.

Such welding as is applicable to power boilers is called "fusion welding." By fusion welding is meant a process of welding metals in the molten and vaporous state without the application of mechanical pressure or blows. Such welding may be accomplished by the oxy-acetylene or oxy-hydrogen flame or by the electric arc.

For some years fusion welding was permitted by the code on power boilers only to those cases where the stress is carried by other construction where the safety of the boiler is not dependent on the strength of the weld, as for instance on a staybolted surface. Also for some years the welding of longitudinal seams was prohibited for pressure above 15 lb. but recently the ban has been lifted provided the work is done in an approved way and now there are high pressure boiler drums being built with welded longitudinal seams which are allowed a factor of safety of 90 per cent in comparison to the factor of 94 per cent for a properly designed quadruple riveted butt and strap joint.

In order to understand something about the so-called approved way let us consider some of the possible defects of welding. Firstly, we may expect the metal melted into place not to have the full tensile strength of wrought steel or wrought iron which acquires a fiber and strength in its fabrication, thus if the metal cannot be built up thicker at the weld we may expect a weak place there.

Secondly, in the process of melting the metal into place unless a reducing or protected flame is used, there may be deposited in the joint various metallic oxides or slag which further weakens the joint.

Thirdly, the manipulation of the welding apparatus is subject to unskilled or careless operation on the part of the operator or what we might call the personal equation.

Fourthly, the cooling of a welded job is sure to leave cooling stresses in the surrounding metal and this can be avoided by a certain amount of preheating of the parts to be welded and after the job is finished the whole piece must be put into an annealing oven and be stress-relieved by heating uniformly and cooling gradually.

Fifthly, discretion must be used as to the cases where fusion welding is peculiarly applicable and where it has been found by experience to be not applicable. In order to undersatnd what is involved here let us look at Fig. 1 which shows a joint just butted up and welded on outside which we will call for convenience a "Putty up" job.

Recently I looked over a couple of different cases of air-tanks with bottom heads welded in after this method. In each case the welded joint had given way and the main part of the vertical tank had gone up through the roof and landed in an adjacent field. One of the first principles of a successful weld is that the edges to be joined shall first be scarfed back as in Fig. 2. In cases where a segment of a boiler head is renewed and both sides of the sheet are accessible it is customary to scarf the sheets from both sides as shown in Fig. 3. If the aforementioned tank head had been put in by the "skirted weld" method it would probably have stood up. This is shown in Fig. 4. Note in Fig. 5 the way a concave head is put onto an ammonia drum. It will be noted that there is little stress on the weld. Figure 6 shows how a nozzle is sometimes welded into a small vertical tubular boiler. It may be secured by a fillet both on inside and outside. Figure 7 shows the approved way of putting a patch on a staybolted firebox lining. The patch meets the old sheet halfway between the staybolts and the old staybolts included at the patch must be removed and replaced by new ones. In this connection a boiler inspector often finds where someone is trying to weld around a leaky staybolt when the proper way is to remove the staybolt, weld up around the hole and rebore and replace the staybolt.

Another mistake commonly found is trying to stop the leaky tubes that have already been expanded several times at the back head by autogenous welding. It is considered all right to weld these tube ends for the sake of tightness when they are first installed.

The writer some time ago was called upon to investigate the wreck of a track locomotive that exploded on account of low water. This boiler had the upper segment of the flue sheet at firebox end replaced at the second row of flues from top. It also had a patch like Fig. 7 rather high up on inner lining of the firebox. The condition of the plates after the wreck showed plainly that both the segment and the patch began to give way first when the water got low. It may thus be inferred that a welded joint is "not so good" to stand overheating.

Since several states have put in force boiler codes like Ohio for instance, which allow welded steam drums it is not expected that this kind of construction will become common at once for the reason that the specifications for the proper and approved fabrication of the welded longitudinal joint is so strict that only a few of the larger manufacturers have the proper shop facilities to make an approved weld, and have the proper annealing oven for "stress-relieving."

Among other things the specifications call for complete X-ray pictures of all the welded longitudinal joints by which hidden defects may be revealed, and also sample test specimens of the weld and hydrostatic tests of the finished drums up to 200 per cent rated boiler safe working pressure.

Logansport, Ind. C. C. CUSTER.

A Request

WE HAVE a request for a simple rule for determining the temperature of saturated steam. This must be simpler than the one published on page 229 of the May 1933 issue, which is (applying from 70 to 120 lb. gage)

$$T = 135\ P^{0.2}$$

Where T is the temperature in deg. F. and P is the pressure in pounds per square inch gage. Readers knowing a simpler rule which is reasonably accurate will confer a favor upon other engineers by writing in to tell us so that the knowledge may be shared with others.

Stored Rotational Energy Replaces Storage Battery

WHEN PURCHASED power fails at the Tennessee Copper Co.'s smelter, an auxiliary source of power is required to operate a 65-hp., 500 v. d.c. motor, for a period of 15 to 20 sec. This motor tilts a large copper converter and prevents molten metal from freezing in the air tuyeres. Originally a storage battery was used to supply this auxiliary power but when the battery failed and it was necessary to obtain another source of power, the rotational energy stored in a 16 ft. diameter flywheel was used in place of purchasing a new battery. The 16 ft. diameter flywheel was on an old Corliss compound steam engine driven direct current generating unit which was not in use. This unit is rated at 250 kw., has a speed of 100 r.p.m. and generates at 500 v. This voltage is the same as that produced by the 300-kw. motor-generator set which furnishes d.c. power for use at the smelting plant.

To make the rotational energy of this flywheel available the following changes were made:

1—The connecting rod was disconnected from the crank arm of the engine so the generator and flywheel could be run without moving the steam end of the generator set.

2—The d.c. generator was then connected to run as a shunt motor, floating on the line to keep the flywheel up to speed.

3—An auxiliary contact was put on the flyball governor of the engine and connected to a relay which trips power off the motor in case it should over speed due to weakening of the shunt field.

Sketch herewith shows the station d.c. bus, feeders, motor-generator set and the way flywheel unit is connected.

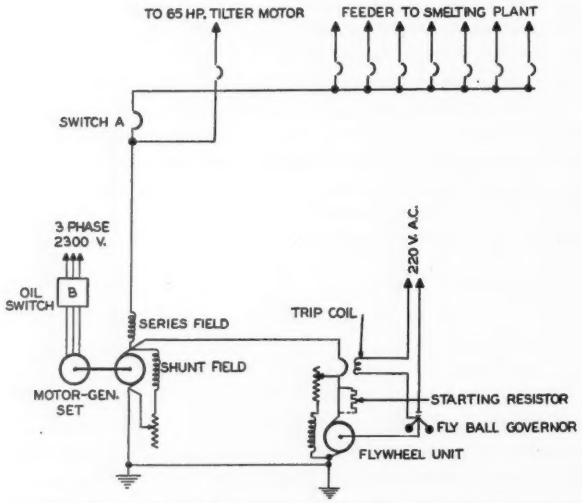


DIAGRAM OF CONNECTIONS FOR SUPPLYING EMERGENCY POWER

To start the flywheel unit, an old 150-hp. d.c. starting panel with resistor was used to supply reduced armature voltage, during the starting period. It was found necessary to have full shunt field voltage at the time of starting in order to develop enough torque to start the flywheel rolling. The unit when up to speed, not only serves as a source of stored energy, but acts as a voltage stabilizer, for whenever the voltage on the d.c. system drops slightly, the flywheel unit immediately acts as a generator tending to prevent the drop in voltage. When the voltage becomes constant the unit acts as a motor to bring the flywheel back to normal speed. Under steady running condition the unit takes 15 amp. to supply the losses.

When a power failure occurs, switch A automatically opens and disconnects all of the plant feeders from the d.c. bus except the 65-hp. tilter motor feeder, which is then energized. Switch B also opens, disconnecting the a.c. side of the motor-generator set from the line, which prevents power from being pumped back into the a.c. bus. The driving motor is of the synchronous type and would act as a generator. Both the motor-generator set and the flywheel unit then give up their rotational energy, supplying power to the 65-hp. motor. The voltage gradually falls on the flywheel unit and in ½ minute it has dropped to 250 v. If the converter happens to be turned out when power fails, the rotational energy is consumed in friction and it takes ¾ of a minute for the voltage to drop to 250.

You will note in the sketch that the flywheel unit is connected ahead of the series field of the motor-generator set. This was necessary as trouble was experienced under certain conditions, with the polarity of the motor-generator set reversing, caused by the flywheel unit feeding power into the motor-generator set. The series field then bucks the shunt field, and if the generator voltage is low a reversal of polarity takes place.

The flywheel unit has been in service for over a year and has never failed to supply the required voltage at the time of power interruptions. For the operation required of it, this unit has proved more satisfactory than the battery that was originally used.

Copperhill, Tenn. L. W. HAYWARD.

A Cause of Boiler Tube Bursting

ONE OF THE LOWER tubes of a water tube boiler nearest the fire failed by bursting, this having been due to the thickness of the tube metal having been reduced over a comparatively local area with the result that it was unable to withstand the pressure. This thinning of the metal had been caused by the erosive action of the solid matter in the flue gases over a period of 16 yr. The parts were smooth and the wasting gradual and therefore not so easily detected as grooving and pitting.

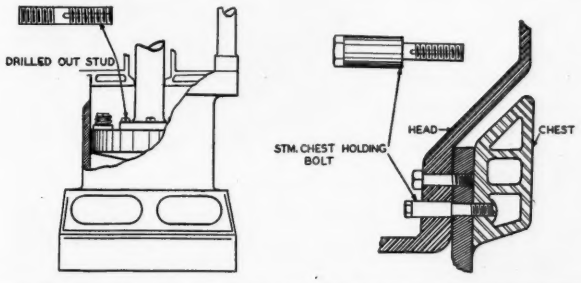
Since this accident all the bottom row of tubes more than 11 yr. old have been replaced with a view to preventing further accidents of this sort. A close inspection is necessary to detect external wasting of this sort due to the erosion of the flue gases, as the wasting is smooth and the thinning extremely gradual. This type of wasting is likely to occur where boilers have seen a great deal of service, or in those where the flue gas speed is high or the gas is heavily charged with abrasive material.

Herts, England. W. E. WARNER.

Center Holes for Stud Bolts

WHEN STEAM TURBINES came to town, the wise ones said that we must forget all we ever knew about reciprocating plants. But from time to time, an old almost forgotten kink that was used in the ancient power house, proves of some advantage in the modern plant.

At one plant, I had a twin air-pump with 36-in. water cylinders. The discharge head was approximately 22 lb.; the suction head or vacuum, was approximately 13 lb. The total load on the bucket was around 35,000 lb. The studs that served to couple the plunger flange and bucket, at the worst possible times, would break.



SOME USES OF STUD BOLTS ON AIR PUMPS AND TURBINES

It was no job for a church member to get inside those 36-in. cylinders and drill out studs. With no center holes for a lead, it was a killer.

So we drilled center holes (see sketch of vertical air pump), and when a stud, or studs, broke, we had a lead hole all ready.

Now we come to the turbine repairs. The same identical scheme is worked on the steam chest holding bolt. The bolt or tap screw measures 8 in., or more, to the shoulder and more than 2 in. in diameter. From that point, the size is dropped to 1 in. It is natural, that the bolt should break at the end of the one inch thread.

Without a center hole, as a lead, it is a desperate job to drill out the broken piece and re-tap; but with the lead hole, the operation is simplified one half. A bushing has to be used, of course, in the large diameter.

Lawrence, Mass. TOM THUMB.

Alteration Cost Prevented By Use of Fan Ventilation

A FEW MONTHS AGO the author was privileged to solve the problem of inadequate ventilation in an underground transformer room. It was gratifying to know that satisfactory results were obtained after considering the conditions under which provisions for increased ventilation must be obtained. These conditions and the method used are outlined as others may be confronted with a similar problem and thus benefit by the experience of one who has encountered this predicament.

A transformer room 7 ft. underground and housing three 75 kv-a. transformers supplying a power load and two 100 kv-a. transformers in parallel supplying a dense lighting load became dangerously hot. Under normal operating conditions sufficient cool air would have been supplied through the manhole cover and entrance shaft, but upon investigation it was found that all five transformers were carrying an overload. The power transformers were overloaded during the day and as soon as their load started to decrease the lighting load came on and continued the heat generating effect, due to the I^2R losses in the transformers, before sufficient time elapsed to permit enough cool air to circulate and cool off the room, walls, and power transformers. This process continued and maintained a high temperature in the room. As the system peak or time of day when the power and light loads overlap had not been reached it was felt that steps should be taken immediately to prevent a transformer failure when the peak occurred. This, of course, would have meant an interruption in service to several large customers.

The first thought was to provide additional ventilating ducts. This would have necessitated breaking the street pavement and building a duct from the bottom of the manhole to the curb line. The object was to obtain a circulation of air through the new duct to the transformer room and then draw off the hot air up through the entrance duct and manhole cover. This would have been the ideal solution, but the expense was rather high in addition to the fact that the entire system including and adjacent to the transformer room was to be connected to a network within a few months. This included the installation of additional transformers in a room near the one in trouble to feed part of the load now carried by it. Also, the transformer capacity was to be reduced from 425 kv-a. to 300 kv-a.

In view of these facts it was felt that some temporary expedient should be resorted to in order to save the expense of building ventilating ducts that would not be required under the new scheme.

Upon close investigation at the room it was found that a spare 5 in. lateral duct existed, from the room to a nearby pole. The thought then occurred, "Why not utilize this duct as an exit for the hot air and feed cool air in through the entrance duct and manhole cover?" This was done, and by installing thermometers the temperature was found to have dropped over 30 deg. F., which allowed a safe operating temperature.

The method employed was to extend the spare lateral 10 ft. up the pole and to connect the other end through a hose to a blower capable of moving 10,000 cu. ft. of air a min. The blower was driven by a 110 v. motor connected to one of the light transformers in the transformer room. A cylindrical shaped tube of canvas was made with wooden supports at each end to give it shape. This tube was installed in the entrance duct and carried to within 12 in. of the floor. The air had a tendency to be sucked through the holes in the manhole cover down the shaft and then forced out through the lateral duct by the blower.

Recording thermometers installed for two weeks gave satisfactory indication that the proper temperature was being maintained for safe operating conditions. From then on, it was necessary periodically to inspect the blower motor, to oil the bearings and make sure it was still functioning.

In this manner it was possible to save several hundred dollars that would have been expended for additional ventilating ducts that would have been required for a period of three months.

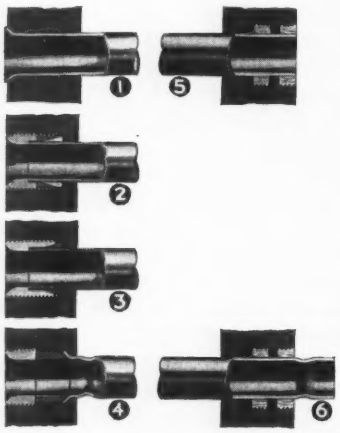
New York, N. Y. J. DUDLEY PEASE.

New Equipment

Condenser Tube Fastening

CRANE PACKING Co., Chicago, Ill., has developed two methods of fastening tubes at the inlet end so as to eliminate rolling and yet firmly fix the tube so as to allow expansion to take place entirely toward the outlet tube sheet.

The first method consists of a gasket inserted into the bottom of the drilling followed by a soft Admiralty metal cone, and a hard Admiralty metal seat. Against the seat is screwed a streamline ferrule, which is designed so as to come flush with the tube sheet as in Fig. 2. An alternate method consists of the gasket, cone and a special ferrule, beveled so as to replace the seat and the ferrule as shown by Fig. 3.



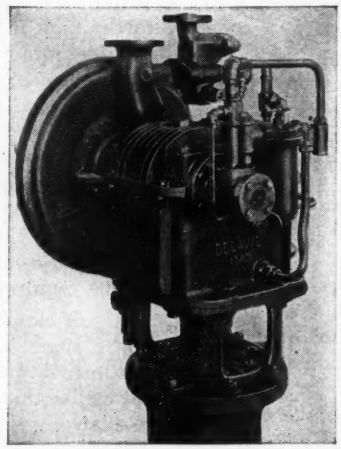
This method used with metallic packing for the outlet end, as shown in Fig. 5, allows the operator to remove tubes from the condenser by removing the ferrule, drifting the tube through the outlet packing and removing it from the inlet end. With care it is possible to slide the tube back and calk the packing so that the unit can again be put on the line without leakage.

The second method of fastening is for tubes necked or damaged by an inferior packing, Figure 4 shows how these same tubes may be refitted so as to move the damaged portion of the tube toward the outlet tube sheet so that metallic packing may be applied to the outlet end with perfect confidence.

Special tools have been designed for both methods. Parts should be of the same material as the tubes to prevent electrolytic action and can be furnished in copper and copper-nickel alloys if desired.

Steam Turbine Driven Fuel Oil Pump

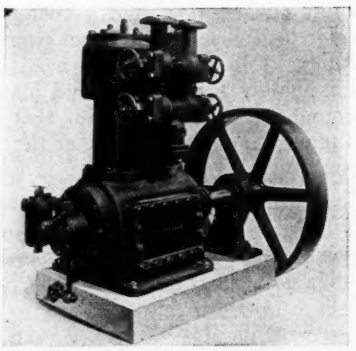
ROTARY DISPLACEMENT pumps for handling oil, whether fuel oil or for lubricating oil, are now built by the De Laval Steam Turbine Co., Trenton, N. J., in a unit, as illustrated, consisting of a De Laval-IMO pump set with the shaft vertical and driven through a worm reduction gear by a high speed steam turbine, the casing of which is mounted on the gear casing.



While this type of pump is in some cases directly connected to electric motors or to steam turbines and is adapted to run at ordinary turbine speeds, the use of the speed reducing gear makes it possible to combine good steam economy with the simplicity and low cost of a velocity stage turbine with only one pressure stage, reducing the steam consumption to about half that of ordinary steam driven pumps. The speed of the turbine is controlled by a small hydraulic governor operating a throttle valve. The unit will deliver oil to burners or to a lubrication system at any rate up to 500 gal. per min.

Refrigeration Compressors

AN IMPROVED SERIES of two-cylinder vertical compressors for ammonia and freon service, in capacities ranging from 1 to 100 t., is being introduced by Worthington Pump & Machinery Corp., Harrison, N. J. This line incorporates tapered rollers for the main bearings and a straight roller type for the outboard bearing. Pressure lubrication is furnished by a gear pump simple in construction and capable of discharging oil regardless of the rotational direction of the compressor.



The suction valve is located in the top of the piston and the discharge valve in an easily removable safety head. Main stop valves, pump-out, safety valves and starting by-pass are incorporated in a self-contained manifold furnished as part of the complete unit. Drive can be either direct connection with synchronous motor, or through Worthington Multi-V-Drive to motor.

Condit Electrical Mfg. Co. Develops New Circuit Breakers

SEVERAL NEW designs of oil circuit breakers have been developed recently by the Condit Electrical Manufacturing Corporation of Boston, Mass. One, a manually operated indoor oil circuit breaker, known as the type E-10, is especially designed for the protection of large motors and for general utility in the industrial field. Another design is a moderate capacity oil circuit breaker for outdoor distribution service suitable for mounting either on pole or framework. This is known as the P-50 type.

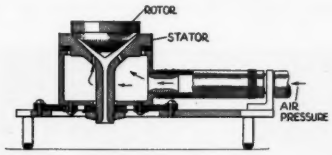
Another new product is a high speed motor operator for application to small switchboard type oil circuit breakers and to subway and

pole line oil switches. This operator is designated as type UC-30. It consists of a universal motor directly connected through a trip free mechanism to the oil circuit breaker. Closure is effected in approximately 8 sec. The motor is suitable for operation on alternating or direct current.

Super Centrifuge

REVOLVING at a speed of 20,000 r.p.s., a small centrifuge exhibited by the Sharples Specialty Co. at the recent Chemical Show in New York, is said to hold the world's record for rotational speed.

As shown by the illustration, the rotor has a conical shape with a maximum diameter of one centi-



meter. It is mounted in a cup, also of conical shape at a slightly different angle. The cone is grooved with a series of flutings and small nozzles are provided in the cup so that compressed air or gas may be directed against the grooves so as to cause rotation.

Air or gas used for rotation escapes between the cone and cup and floats the rotor free of any mechanical contact. The increased velocity of the gas passing the rotor causes a decrease in pressure, i. e., a suction, which holds the rotor in place, even though the machine be inverted. Maximum speed is obtained with hydrogen under 160 lb. pressure.

The most practical method of measuring this speed is found to be a mirror rotating at a definite and known speed, using the same principle used in measuring the velocity of light.

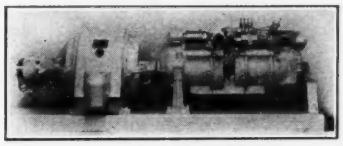
This super-speed centrifuge is being placed in the Franklin Institute at Philadelphia as a permanent exhibit.

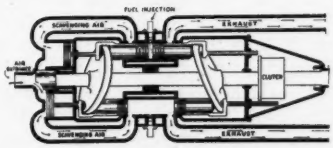
Crankless Diesel

AN INNOVATION in Diesel engine design is found in the new crankless, two cycle engine now being built by the Sterling Engine Co., 1250 Niagara St., Buffalo, N. Y., in sizes up to 625 hp. One of the smaller units, a 1750 r.p.m. engine direct connected to an 80-kw. generator is shown by the photograph and the fundamental operating principles of the new engine built under license from A. G. M. Michell by the drawing.

Fundamentally the engines consist of four or six horizontal cylinders, each with two opposed pistons, arranged concentrically around a crank assembly consisting of the crank, two wobble plates, or, inclined discs, and a scavenging air distributing valve. Fuel is injected into the compression space between the pistons and the pistons, moving away from each other, bear on the inclined discs and cause the shaft to rotate.

One of the interesting features of the engine is the piston type scavenging blower. The air pis-





tons, driven directly from the back of the power pistons, compress the air to from 4 to 6 lb. ga. A single air distributing valve on the crank serves all cylinders and is the only valve used, the principle of operation being clearly shown at the left hand side of the drawing.

Overall dimensions are comparable in size to a gasoline engine of the same power but the head room is considerably less. Weight per horsepower ranges from 13 to 20 lb. In the photograph the mushroom shaped hood at the right is the air intake. At the left of the intake are the starting and control levers, the fuel pump, the exhaust manifold and the starting motor. The shape of the engine is well adapted for streamlining for mobile use.

The smallest model has a continuous rating of from 45 to 125 hp. over a speed range of 600 to 1800 r.p.m. and measures 50 in. long, 22 in. wide and 29 in. high. The largest, rated at 325 to 625 hp., 600 to 1200 r.p.m., measures 100 in. long, 50 in. wide and 57 in. high. The two intermediate sizes are rated at 300 and 500 hp. at the maximum speed of 1500 r. p.m.

New Intake Air Cleaner

THE BURGESS BATTERY CO., Madison, Wis., has developed, for use on internal combustion engines, an air cleaner which has high cleaning efficiency, low air restriction and ease of cleaning the

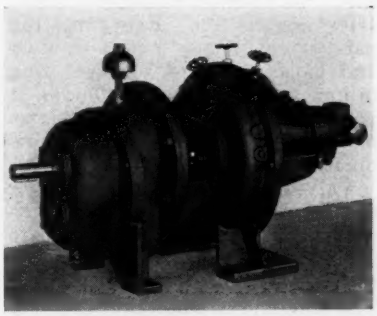
replaceable filter cartridge. This filter works on the viscous coated fiber principle, a cellulose fiber filtering material being used for this purpose.

Burgess air cleaners are designed for a maximum air velocity of 270 ft. They are made in two standard sizes; the smaller one, 5¾ in. diameter and 4½ in. long, having a capacity of 80 cu. ft. per min.; the larger flat unit 9 by 17 by 2 in. having a capacity of 290 cu. ft. per min. Either the round or flat type may be used in multiple for larger capacities.

Steam Turbine-Speed Reducer Units

BY INTRODUCING the principle of combining built-in speed reducers with steam turbines, the Coppus Engineering Corp., Worcester, Mass., has made possible direct driving of inherently lower speed machines such as pumps, blowers and mixers.

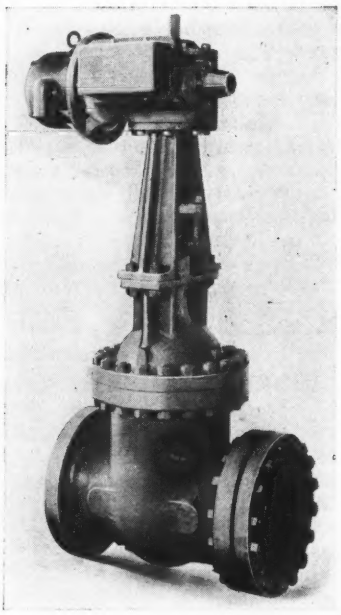
The built-in speed reducers can be supplied with either single reduction or double reduction units, and for clockwise or counter-clockwise rotation. These machines are compact in design and the fact that they take up little floor space is an important consideration in many installations.



All gears, in single and double reduction units are of the herringbone type (double helical) which is best suited for the speed reducer type of drive in which high primary speeds are used.

New Limitorque Valve Operator

THE PHILADELPHIA Gear Works have completely redesigned the Limitorque Electric Valve operating mechanism so that it is now more correct in principle and application. This control consists of a self-contained reducing gear unit with mechanical and electrical limit built into the mechanism. The valve operating nut that raises and

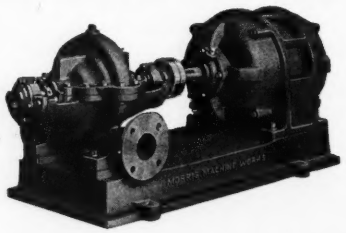


lowers the valve disc is incorporated in the casing and is supported by heavy duty Timken roller bearings. The motor which operates at 1800 r.p.m. is first reduced by a low ratio helical gear and the final reduction is by a steel and bronze worm gear. The whole mechanism is immersed in oil and needs no attention for 6 months after installation. Every moving part is completely enclosed, dust and moisture proof for operating in any atmosphere or outdoors. It is made in 3 sizes which with two motors per frame allows of 6 combinations.

Valves of 3 to 72 in. diameter are listed as operable by the various machines, and sizes from 3 to 24 in. are capable of pressures up to 600 and 1000 lb. per sq. in. The machine is adaptable to every form of gate and globe valve, sluice gates, dampers, heavy factory doors, garage doors, monitor sash operation and for any mechanism having a definite movement that must be stopped or reversed at the end of travel. It is equally adaptable to existing hand operated valves.

High Speed Pumps

DOUBLE SUCTION split case ball bearing pumps of new design for operation at high speed are announced by Morris Machine Works, Baldwinsville, N. Y. These pumps,

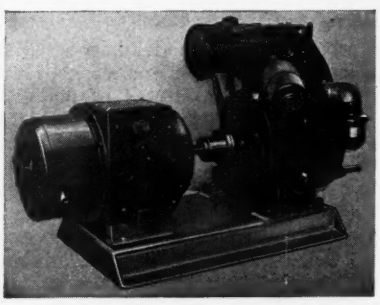


developed for direct connection to electric motors and steam turbines at 3500 r.p.m., are built in sizes from 1½ to 5 in., capacities up to 850 g.p.m. and heads of up to 50 ft. Heads higher than this can be taken care of by connecting two pumps in series on a single bed plate. They are also made for belt-drive or gear drive for use with gasoline engines.

Harnischfeger Small Lighting Plants

ELECTRIC GENERATING UNITS in small sizes were recently announced by the Harnischfeger Corp., 4400 W. National Ave., Milwaukee, Wis. This small, heavy duty line of lighting units consist of a one or two cylinder gasoline engine directly coupled to a compound wound, continuous generator. Push button or manual starting is available.

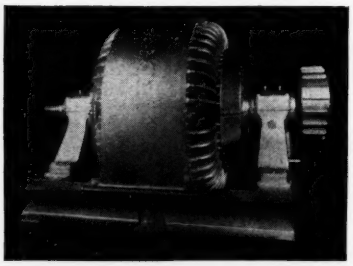
Capacities range from 400 watts to 3 kw., 35 or 120 v. dc. Greater capacities are provided for by 4



and 6 cyl. gasoline generator sets with a current range of 1.5 to 60 kw. In addition to the gasoline driven sets, Diesel power is also available in capacities of 35 and 50 kw. ac. or dc.

New Totally Enclosed Motor

ELECTRIC MACHINERY MFG. Company, Minneapolis, Minn., announces the development of a totally-enclosed, fan-cooled sychronous motor. This motor is designed for use in locations where corrosive atmospheres prevail, or where motors are subject to salt-water or other sprays. Working parts of the motor are totally enclosed, and sealed from exterior atmosphere; the motor exterior is



treated to prevent corrosion. Motor cooling is secured by internal recirculation of air. These synchronous motors are available in practically any horsepower or speed rating to meet any kind of corrosive atmospheric condition.

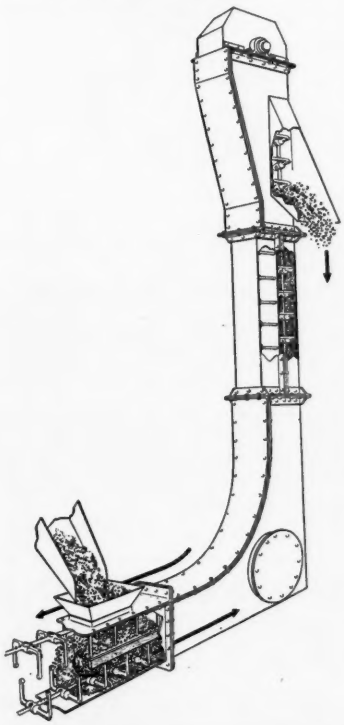
Transparent Draft Gauge

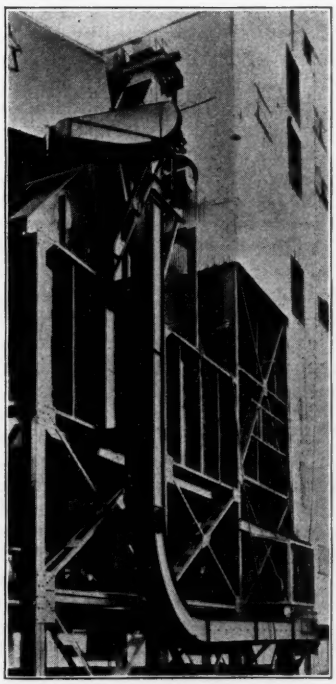
CLEAR WATER WHITE blocks of Bakelite transparent resinoid, made by the Bakelite Corp., Bound Brook, N. J. are employed for Dwyer draft gages. The inclined

tube and oil chambers are accurately reamed in the solid casting. Since there is no metal casing, all parts are fully visible and the leveling bubble is free from shadow and easy to read.

Redler Conveyors

EVEN ONE of the Baron's extravagant inventions could cause no more skepticism than the new Redler conveyor, insists one of the licensees, Stephens Adamson Mfg. Co., Aurora, Ill. The only real difference is that this conveyor works while the Baron's are what may be expressed diplomatically, as, still in the experimental stage.





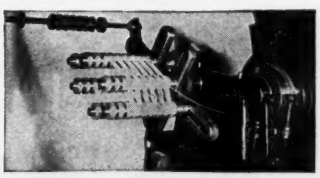
The new conveyor handles free flowing bulk material such as coal, grain, flour, etc., horizontally, up inclines, vertically or around corners through an enclosed steel or wooden trough. Both construction and operation are shown by the drawing and an installation handling coal is shown by the photograph. Material is loaded into the conveyor trough at any point along a horizontal or nearly horizontal run. Ordinarily the trough is filled to completely bury the conveying element and allow the conveyor flights to actually float clear of the trough. When once loaded, there is no relative motion between the load and the conveying element until they reach the discharge point.

Simplicity of discharging at any point is another feature of this new conveyor-elevator. Horizontal or inclined sections can be discharged through bottom openings wherever needed. Vertical legs are discharged by opening one or more of the side walls. The conveyor operates most efficiently when carrying a full load. So, when capacities are to be varied, some form of variable speed drive is recommended.

As is natural with a new product such as this continuous-flow conveyor, new applications and arrangements are constantly being perfected the licensees saying that the next step may easily be a closed circuit conveyor that will carry horizontally, elevate vertically and carry over to a second horizontal run. Such a conveyor could fill a whole row of bins and finally carry back to the loading point where it would refuse to accept more.

Universal Coil Winder

THE UNIVERSAL coil winder shown in the accompanying illustration should prove of value in any plant where it is necessary occasionally to do motor repair work.



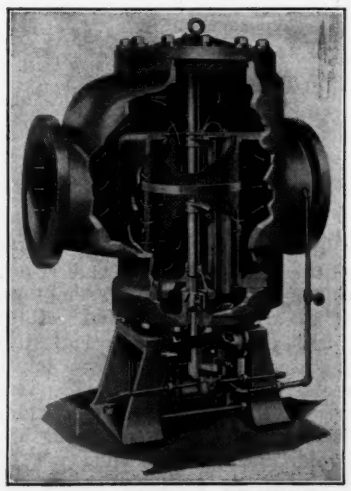
This device which has been placed on the market recently by the Ideal Commutator Dresser Co. is simple and can be adopted for use on any lathe or other rotating spindle. It is highly flexible and set up from one type of coil to any other type and can be made in a few minutes. Having no solid sidewalls, each layer of field or transformer coils can be laced with tape so when the machine is collapsed, the coil needs no tying to keep it from springing apart.

Diamond coils are made in series of any number up to eight. This not only eliminates series connections in pole groups, but gives a better and neater job. An average set of 48 Diamond coils is made in from 30 to 45 min. Rotor and stator coils for Wagner and similar types of repulsion induction motors are made just as quickly.

Self-Cleaning Strainer

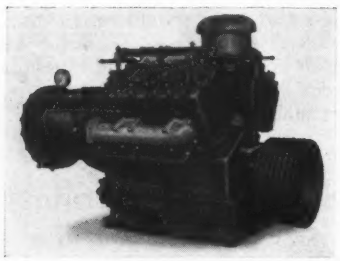
SELF CLEANING STRAINERS, to clear service water of extraneous matter and small particles, which do not need to be opened up for long periods, have recently been developed by the Elliott Co., Jeannette, Pa. The mechanism includes a self-contained water motor which takes the water supply from the outlet side of the strainer, no external source of power being required.

Interior construction of the strainer is shown by the illustration. The strainer basket is made up of three thicknesses of perforated plate or mesh, the outside being a Monel wire cloth with 0.02 in. openings. A variable speed V-shaped scraper is operated by the motor at the bottom. Due to the shape of the strainer there is a back flow through the coarse mesh which flushes dirt through the revolving V-shaped scraper to the drain. These strainers are built in sizes ranging from 4 up to 24 in. for 125 lb. working pressure.



Gardner-Denver V Type Compressors

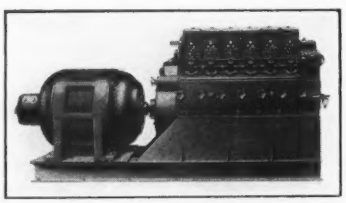
INTRODUCTION of a new line of vertical compressors has just been announced by the Gardner-Denver Co., Quincy, Ill. Inlet and discharge valves are cushioned and are silent. Extra large water jackets completely surround the cylinders and valves and a water cooled



inter-cooler has been included to cool the air between stages. Crankshafts are forged steel, supported by three main bearings of the bronze-packed babbitt-lined full circle type. There is pressure feed lubrication to all bearings through drilled passages by a rotary oil pump.

Small Diesel Generating Sets

TO MEET THE DEMAND for small primary power equipment, Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill., has recently placed on the market a lightweight four-cycle Diesel engine designed for marine, mobile or stationary service and available in sizes 10 to 60 b.hp. The cylinder size is 4¼ by 6 in. and the normal operating speed 1200 r.p.m.; the



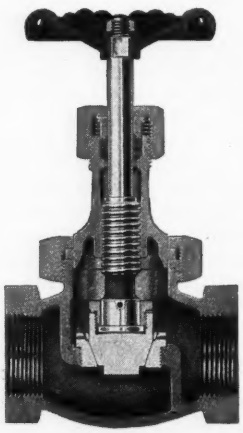
cylinders in the multi-cylinder engines are cast en-bloc and removable cylinder liners are employed in all sizes. Intake and exhaust valves are made of a special alloy, operated by push rods from totally enclosed camshaft. Fuel pumps are of the individual mechanical injection type with fixed length of stroke and variable inlet cut off.

The single cylinder engine can be readily started by hand cranking. On the two and three cylinder units hand cranking is the standard starting arrangement with 24-v. electric starting equipment offered as special equipment. The four, five and six cylinder units are fitted with a complete electric starting system as standard equipment.

For electric generating service, these engines are available equipped with either a.c. or d.c. generators in capacities of 6 to 40 kw.

Severe Service Valves with Alloy Trim

FOR SEVERE SERVICE demanding maximum resistance to destructive action on valve seat bearings, The Lunkenheimer Co., Cincinnati, O., has developed Renewo and Ferrenewo Valves with plug type NS5

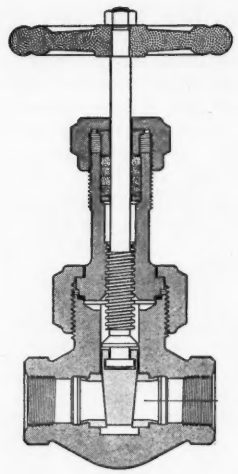


Alloy Seats and Discs. NS5, a new alloy, is a non-galling, hard (300 Brinell), non-ferrous composition resistant to wear, abrasion, erosion and corrosion, which retains its hardness at high temperatures.

Iron body bronze mounted Ferrenewo Plug Type valves are made for 150 lb. while the bronze Renewo valves are available in both 200 and 300 lb. patterns.

New Vogt Valves for High Pressures

HENRY VOGT MACHINE CO., Louisville, Ky., recently announced several new type valves, one of which is shown herewith. It is a drop forged steel gate valve with union bonnet and inside screw stem, the bonnet having a gasket or ground joint as desired. The wedge is solid and the seats are



rolled in and may be easily removed.

These valves are available in sizes from ¼ to 2 in.; are designed for oil or steam service up to 600 lb. at 800 deg. F. or non-shock cold working pressures up to 1500 lbs. and may be repacked while under pressure. Furnished with steel, stainless steel, Nitralloy or Monel metal trimmings to suit the intended service.

Milwaukee and Rockford Industrialists Elected M. A. P. I. Executives

ELECTION OF Leo W. Grothaus, of Milwaukee, and Robert M. Gaylord, of Rockford, to its executive committee is announced by the Machinery and Allied Products Institute. The Institute, which has been the leader in the code deliberations of the capital goods industry of the country, is headed by John W. O'Leary, of Chicago.

Mr. Grothaus, an officer of the Allis-Chalmers Manufacturing Co., is the third prominent figure in Milwaukee industrial circles to be honored by the M.A.P.I. membership. The other two are Robert E. Friend, of the Nordberg Manufacturing Co., and C. S. Wagner, executive of the Koehring Co.

Mr. Gaylord, who is president of the Ingersoll Milling Machinery Co., is former president of the National Machine Tool Builders Association. His election to the M.A.P.I. board gives Rockford two spokesmen. The other is A. M. Matteson, president of the Matteson Machinery Works. Mr. Grothaus will represent the Rock and Ore Crusher Association in the M.A.P.I. councils.

News From the Field

FRANK W. KENNEDY, vice president and general manager of the De Laval Steam Turbine Co., Trenton, New Jersey, died at his home at Yardley, Pa., on January 24, 1934, after a short illness. Mr. Kennedy was born at Pittsburgh, Pa., in 1876, and attended the Shadyside Academy of that city. He graduated from Princeton University with the degree of Civil Engineer in 1898, and thereafter occupied positions successively with the Pennsylvania Railroad at Altoona, the U. S. Steel Corp., at one of the Ohio subsidiaries, and the Dravo-Doyle Co., Pittsburgh. In 1908 he became general manager of the De Laval Steam Turbine Co. at Trenton, and in 1916 was elected vice president. He was a director of that company and also president and director of the American Bauer-Wach Corp., with offices in New York. Other connections included membership in the executive committee of the Machinery Builders Society, the Society of Naval Architects and Marine Engineers, the Trenton Club, and the Trenton Country Club. He was vice president of the Wilbur Trust Co., and a director of the First Mechanics National Bank, Trenton, New Jersey.

THE ELGIN SOFTENER CORP., Elgin, Ill., announces the appointment of the L. A. Snider Engineering Service, 605 North Michigan Avenue, Chicago, as representative of its entire line of water conditioning equipment in the northern Illinois and Indiana territories. Offices will be maintained in Indianapolis and Peoria as well as in Chicago for sales and engineering service of the Elgin equipment which includes boiler water deconcentration, continuous blow down and heat exchanger systems, boiler water chemical control, and industrial water softeners.

INGERSOLL-RAND CO., New York City, has acquired the turbo-blower business of General Electric Co. and will consolidate it with its own turbo-blower department. This acquisition places Ingersoll-Rand in position to meet demands for blowers and centrifugal type compressors for the broadest possible variety of uses. The manufacturing equipment previously employed by General Electric is being moved to Ingersoll-Rand's Phillipsburg, N. J., plant where all types and sizes will be manufactured.

GORDON FOX has been elected vice-president of the Freyn Engineering Co., a firm of steel mill consulting engineers in Chicago. Since 1920 Mr. Fox has been power and electrical engineer of this company. The past 5 yr. have largely been spent in the U. S. S. R., where Freyn Engineering Co., in association with the Russian organization, Gipromez, has coöperated in the development of the steel industry of the Soviet Union. After his graduation from the University of Wisconsin in 1908, Mr. Fox was associated with the General Electric Co. in several capacities until 1914. Between 1914 and 1920 Mr. Fox was electrical engineer of the Steel and Tube Co. of America and its predecessor, the Mark Manufacturing Co. During this period was constructed the Indiana Harbor Works of this company, which later became the western plant of the Youngstown Sheet and Tube Co. He is the author of many articles which have appeared in POWER PLANT ENGINEERING and other technical publications, and has written two books dealing with motors and control for industrial equipment.

JEFFREY MANUFACTURING CO., Columbus, O., has opened offices in the Carew Tower Building, Cincinnati, and in the Rockefeller Building, Cleveland. Lyle Martin will represent the company at the Cincinnati office and G. D. Francisco and J. R. Warren at Cleveland, to deal with industrial elevating, conveying and reduction problems.

FORMATION of Wilbin Instrument Corp., 40 East 34th St., New York, N. Y., has just been announced. The company plans to manufacture and market a complete line of novel electric instruments for the control of temperature, humidity, pressure, vacuum and liquid levels as used in heating, air conditioning, refrigeration, and the process industries. The officers are Gus A. Binz, President, Clement Wells, Vice President, E. A. Ileman, Director and Chief Engineer.

IN ACCORDANCE with the resolution adopted at Stockholm in 1930, the Fourth International Congress for Applied Mechanics will be held in Cambridge, England, July 3 to 9, 1934. An English organizing committee has been formed and advises that the universities and colleges will be pleased to welcome the Congress. The subjects to be discussed will be grouped under the four general headings: 1. Rational Mechanics, including vibrations of structures and machines. 2. Mechanics of Fluids, including turbulence, the boundary layer, heat transfer, and compressible fluids. 3. Materials, including elasticity, plasticity, fatigue, and crystal structure. 4. Water Waves, including resistance and stability of ships and seaplanes. The Applied Mechanics Division of The American Society of Mechanical Engineers is coöperating with the committee with the idea of coördinating the participation of other American groups in this Congress.

THE METROPOLITAN REFINING CO., Inc., Long Island City, N. Y., announces the appointment of Albert P. DePuy as advertising manager. Mr. DePuy was formerly editor and advertising manager of the Universal Engineer.

A. M. BYERS CO., Pittsburgh, Pa., has announced the appointment of J. B. Durkee, February 1, 1934, as manager of the company's Houston, Tex., office. Mr. Durkee formerly represented the company in the Houston territory and more recently has been stationed in Tulsa.

FORREST U. WEBSTER, for the past seven years advertising manager, Cutler-Hammer, Inc., Milwaukee, has been appointed manager of merchandising sales.

A. G. PRATT, president of The Babcock & Wilcox Co., has recently been elected to the board of directors of the Worthington Pump & Machinery Corp.

J. VERNER SCAIFE, JR., has been elected to succeed his brother, Alan M. Scaife, as president of Wm. B. Scaife & Sons Co., Oakmont, Pa. Alan M. Scaife will continue activity in the capacity of vice-president but as he has recently been elected chairman of the board of the Pittsburgh Coal Co., his new duties will require a considerable portion of his time.

E. F. HOUGHTON & Co., Philadelphia, announces the election of the following officers: President, Louis E. Murphy; First Vice-President and General Manager, Maj. Aaron E. Carpenter; Second Vice-President and Director of Sales, George W. Pressell; Secretary, A. E. Carpenter, III; and Treasurer, Dr. R. H. Patch.

C. R. MESSINGER, Chairman of the Board of Chain Belt Co., Milwaukee, has resumed the post of president of the company, left vacant by the sudden death of his brother, Clifford F. Messinger, in December. For the past 3 yr. C. R. Messinger has been president of the Oliver Farm Equipment Co. and was recently elected Chairman of the Oliver Board. In resuming the presidency of Chain Belt Co., Mr. Messinger again takes over the active management of a company with which his name has long been associated. G. K. Viall, a Vice-President, was elected to the vacancy on the Chain Belt Board, created by the death of Clifford F. Messinger. He has been with the company since 1921, serving successively as assistant to president, works manager, and vice-president.

AT THE ANNUAL meeting of the stockholders of The Connersville Blower Co., Inc., held on January 23, 1934, action was taken to change the name of the company to Roots-Connersville Blower Corp., thus indicating to the public the units making up the company. The management of the company will continue as heretofore, without any change in personnel.

ANNOUNCEMENT is made of the licensing by the Falk Corporation of Milwaukee, of J. D. Christian Engineers, San Francisco, Calif., for the manufacture of Rite-Lo-Speed motors under the original Christian design. The Falk Corporation is the new owner of the U. S. patent originally issued to J. D. Christian.

ELECTRICAL ENGINEERING PRACTICE. By J. W. Meares and R. E. Neale. Published by Chapman & Hall, Ltd., 11 Henrietta St., W. C. 2, London, England. Cloth, 5½ by 8½ in., 1060 pp. Price, 30 shillings (about $7.50).

This is the third and final volume of the fourth edition of this popular book which for completeness rivals a handbook but in nature is a comprehensive text. The first part of this volume deals with electric motors and their controls treated from the practical standpoint of fundamental principles of operation, available characteristics and suitable applications. Other chapters deal with various specialized industrial process, particularly chemical and metallurgical. The language is clear, the text concise and the illustrations well chosen, the fundamental treatment being such that the material is as applicable in this country as in England. Indeed in data and illustrations, literature of this country and continental Europe are well represented. The last part deals with specifications, testing, depreciation and law.

For the Engineer's Library

MECHANICAL WORLD YEAR BOOK. Published by Emmott & Co., Ltd., 31 King St. West, Manchester, England. Cloth, 3 by 6 in., 361 pp.

Several new sections have been added to the 1934 edition of this popular handbook. Of these sections, metals and alloys are the most important in our field as the wide range of materials now available to the engineer makes a knowledge of their properties a necessity. Machine tools and press work are dealt with in other new sections, the balance of the book covering the same field of mechanical engineering as did the former editions.

TENTATIVE STANDARDS of the A.S.T.M. Published by the American Society for Testing Materials, Philadelphia, Pa. Size 6 by 9 in., 1136 pp. Price, paper, $7; cloth, $8.

The term tentative is applied to proposed standards published for one or more years for the purpose of eliciting criticism before being formally adopted by the Society. These are published annually. This year's volume covers 223 tentative standards which include 34 for ferrous metals; 21 for non-ferrous; 45 for cement, lime, stone, etc.; 113 for miscellaneous materials such as paint, petroleum, insulation, etc., and 10 for general testing methods applying to materials. This volume also includes proposed revisions to standards published for the purpose of eliciting criticism.

HEAT POWER ENGINEERING (Parts II and III). By William N. Barnard, Frank O. Ellenwood and Clarence F. Hirshfeld. Published by John Wiley & Sons, 440 Fourth Ave., New York, N. Y. Size 6 by 9 in., cloth. Part II, 849 pp.; Part III, 405 pp.

These two volumes (together with Part I, Thermodynamics and Prime Movers published earlier) represent a complete treatise on heat power engineering. Although intended primarily as a text for an undergraduate engineering course the logical arrangement and clear comprehensive treatment makes it of unusual value to the engineer. References to detailed treatments in other texts and contemporary publications are complete. Part II covers steam generating apparatus and prime movers, fuels, combustion and heat transmission dealing primarily with the basic thermodynamics, structural and operating principles and to some extent with the economic factors and elements of selection. Part III covers auxiliary equipment, air conditioning and refrigeration including plant ensemble, economics and cost data.

POWER SUPPLY ECONOMICS. By Joel D. Justin and William G. Mervine. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Size 6 by 9 in., 255 pp. cloth. Price, $3.50.

To those charged with the responsibilities of maintaining or providing an adequate and dependable power supply, the matter of economics cannot be overlooked. Steam hydro and power compete with each other and, in the case of industrial plants, with utility service. Minimum costs, additional capacity, a new plant or modernization are always present and are discussed at some length in this book from a background of many years experience.

THE AMERICAN SOCIETY for Testing Materials has just issued its Book of A.S.T.M. Standards. The 1933 issue of this publication is composed of two parts aggregating 2300 pp. Part I contains all A.S.T.M. standards covering metallic materials; Part II, all standards relating to non-metallic materials.

In both parts of the book, the specifications for a particular class of material are given first, followed directly by the test methods, definitions, etc. A complete subject index is included in which each standard is indexed under the principal subject covered, keywords being given in alphabetical sequence. This index, together with two tables of contents, greatly facilitates the use of the book.

Of the 185 standards in Part I, 104 cover the ferrous metals, steel, wrought iron, pig iron and iron castings and ferro-alloys, while 70 relate to non-ferrous metals, including aluminum and magnesium alloys, copper and copper alloys, lead, nickel, zinc, bearing metals, solder metal deoxidizers, electrical-heating and electrical-resistance alloys. Eleven of the standards involve metallography and general testing methods.

Part II contains 285 standards, 37 of which were adopted in 1933. Revisions in several important standards also were adopted this year. Those materials covered by standards in which important changes were made include:

Refractory Materials (porosity and volume change tests), Sands for Concrete (organic impurities test), White Pigments (routine analysis), Petroleum Products (cloud and pour point, and viscosity test), Structural Timber, Joists, Planks, etc., Creosote Oil (sampling and analysis), Molded Electrical Insulation (tests), Tire Cord (woven and on cones), Cotton Sewing Threads, Asbestos Yarns.

Copies of the book can be obtained from A.S.T.M. Headquarters, 1315 Spruce Street, Philadelphia, Pa., at the following prices: Either part, $7.50; both parts, $14.00.

BULLETIN OF THE INDUSTRIAL RESEARCH LABORATORIES OF THE U. S. Fifth Edition. Compiled by Clarence West and Callie Hull for the Research Information Service of the National Research Council. Paper covered, size 6¾ by 9¾ in. Published by The National Research Council of The National Academy of Sciences, Washington, D. C., 1933. Price $2.00.

This edition of this bulletin contains information regarding 1575 industrial and consulting laboratories in the United States. The names and addresses of these laboratories are given, their research staff and the character of the research work.

AMERICAN ELECTRICIANS' HANDBOOK. By Terrell Croft. Third Edition. Revised by Clifford C. Carr. Bound in semi-flexible imitation leather, size 4½ by 7 in. 1052 pages, illustrated. Published by the McGraw-Hill Book Co., Inc., New York, 1932. Price $4.00.

This valuable handbook has stood the test of time well and in this, its third edition, it contains more practical information than ever. Mr. Croft, however, was unable to undertake its revision so the task was delegated to Clifford Carr who is a professor of electrical engineering at Pratt Institute.

This is essentially a practical man's handbook. In compiling it, the aim has been to collect such information as will enable practical electrical men—wiremen, power plant superintendents and operators, plant electricians, linemen, etc., to select and install commercial electrical apparatus and materials intelligently and to qualify them for operating the equipment after it has been installed. Although it is not a so-called "theoretical" book it is theoretical to the extent that the information it gives is based on sound physical laws. Illustrations and diagrams are used freely and wherever necessary special problems are solved to indicate the proper application of the rules which are given.

The material is presented under six general headings: 1. Fundamentals; 2. Generators and Motors; 3. Outside Distribution; 4. Interior Wiring; 5. Transformers, and 6. Electric Lighting.

In the revision, every effort was made to follow the method of the original author in including only practical information set forth in simple language.

METAL & THERMIT CORP., New York, N. Y., has just published a booklet entitled Thermit Welding—Industry's Master Maintenance Tool, dealing with this alumino-thermic process which has been successfully employed in the welding of heavy sections of ferrous metals. Particular attention is given to the economy and permanency of Thermit repairs and actual cost data are given in a number of instances.

THE BAYER CO., St. Louis, Mo., has just issued a folder dealing with the Bayer Model-E-Automatic Ratchet Operating Head for soot blower application.

WORTHINGTON PUMP AND MACHINERY CORP., Harrison, N. J., describes in a 28-page bulletin the Worthington feather valve compressors of the horizontal duplex motor-driven type for direct-connected and belted drive. Another bulletin issued by the corporation is entitled "Worthington Monobloc Centrifugal Pumps", which gives useful data relative to this equipment.

ELLIOTT CO., Jeannette, Pa., has issued a revised edition of its bulletin describing twin strainers. Types described and illustrated include twin strainers for low and high-pressure service, a compact unit for small space, a multiple basket unit with extra large straining area, motor-operated units in the larger sizes; also twin oil strainers and single strainers.

INDEX TO STANDARDS and tentative standards of the American Society for Testing Materials has recently been published and can be obtained from the headquarters of the society at 260 S. Broad St., Philadelphia.

ENGINEERING AND INDUSTRIAL American Standards approved by the American Standards Association, 29 W. 39th St., New York, is now available. Hundreds of these standards have been completed, ranging in cost from $0.05 to $1.50, the complete set costing $60.55.

TIMKEN ROLLER BEARING Co., Canton, O., has recently released a new 266-page loose leaf book of general information on the various types of Timken bearings. It differs materially from previous editions since new load ratings have been established conforming to the fatigue life of the bearings. An explanation of these ratings along with the methods of calculating loads and selecting bearing comprises one section. The entire book is filled with technical and commercial data extremely useful to the man who selects bearings and has charge of operation.

PERFORMANCE AND TEST STANDARDS for self-priming centrifugal pumps is discussed in an engineering handbook just published by the LaBour Company, Elkhart, Ind. in the interest of those who buy, sell, specify or use such equipment. It includes test methods and standards for measuring the performance of pumps of this type.

DEVELOPMENTS of the Busch-Sulzer Bros. Diesel Engine Co., St. Louis, Mo., during the depression period are covered in a new bulletin. Six new engines include the world's largest locomotive Diesel and the World's largest trunk piston Diesel, this latter being built with 30 by 52 in. cylinders in sizes up to 10,000-hp.

HAYNES STELLITE Co., Kokomo, Ind., described many hard-facing applications in a 96-page booklet entitled "Hard-Facing with Haynes Stellite Products," recently issued. A detailed description is also given of various hard-facing materials and the correct procedure for their application by both the oxy-acetylene and electric-arc processes.

DESCRIPTIONS of Condensators, Styles 33 to 37, with applications, physical dimensions and directions for installation are included in a 6 p. booklet issued by Barnes & Jones, Inc., 128 Brookside Ave., Jamaica Plains, Boston, Mass. The fundamental purpose of the Condensator is to return the water of condensation to the boiler from open return line systems, independently of boiler pressure.

SARCO Co., New York City, is distributing an attractive folder entitled New Radiator Traps for Old which deals with this phase of plant modernization.

EQUIPMENT for liquifying CO_2 gas after it has been reclaimed from the fermenter and for storing and cooling CO_2 gas under pressure is described in two new bulletins issued by the Carbondale Machine Co. of Carbondale, Pa.

FLUID METERS, Their Selection and Installation. Published by the American Society of Mechanical Engineers, 29 W. 39th St. New York, N. Y. Size 8 by 10 in., paper, 39 pp. Price $1.50

This is the third and concluding part of the report by the Special Research Committee of the society. The first part, published in 1924, dealt with the theory and application of meters, the second part, published in 1931, described the various meters and the concluding part discusses in detail the selection of meters for various services and their installation to give the best service. Justification for this detailed treatment is given by the committee in its foreword, "It is hoped that this section will impress users with the importance of correct meter installation and the vital necessity for continuous supervision, which is apparently lacking in so many cases today."

FIVE NEW tentative standards recently published by the American Society for Testing Materials, 260 South Broad St., Philadelphia, can be obtained from the headquarters of the society for 25c each. These standards are: Testing High Temperature Heat Insulation; Testing Rubber Belting used for Power Transmission; High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (up to 2 in. and from 2 to 4 in.); Lap Welded and Seamless Steel Pipe for High Temperature Service.

THE CARBONDALE MACHINE Co., Carbondale, Pa., has just issued Bulletin 1133 under the title "Carbondale Combined Units with Duplex Vertical Ammonia Compressors." The bulletin covers the details of the Carbondale compressors as applied to combined units and gives up to date details such as tapered roller bearings, strip plate inertia valves, Cooke seal packing and other modern improvements which are features of these units.

THE SHARPLES SPECIALTY Co., Philadelphia, in a catalog entitled "The New Sharples Laboratory Super Centrifuge" describes this recently developed apparatus which will find application in many power plant laboratories.

THE RIVERSIDE METAL Co. of Riverside, N. J., has recently published booklets on Riverside Phosphor Bronze, Nickel Silver and Beryllium Copper, also a folder on free-cutting Phosphor Bronze and Nickel Silver. This series makes very interesting reading and contains a great amount of information useful to engineers confronted with the problem of selecting alloys for particular industrial purposes.

JOHNS-MANVILLE, New York City, has published a folder on Johns-Manville industrial friction material which covers the various types of friction material made by this company and their selection for specific use in industry.

REPUBLIC STEEL CORP., Massillon, Ohio, under the title "Enduro" Republic's Perfected Stainless Steel, has issued a brochure dealing with types, finishes, applications, fabrication data and installation methods which will be found of interest and value to men having to use special types of stainless steels in structural work.

HARBISON-WALKER REFRACTORIES Co. of Pittsburgh, Pa., has issued a pamphlet entitled "One Test Proves . . ." which deals with fire clay for bonding.

HOMESTEAD VALVE MFG. Co., Coraopolis, Pa., has just issued a 24-page pocket edition catalog on quarter turn valves which contains an interesting description of the quarter turn valve principle involved in the Homestead valves and covers a number of two, three and four way valve hook-ups for various fluids, gases and vapors.

POOLE FOUNDRY & MACHINE Co., Baltimore, Md., has recently issued its catalog 34 dealing with flexible couplings, their value and many advantages. The various kinds and types of couplings are illustrated, complete with horsepower ratings, maximum speeds, dimensions and weights.

POSSIBLE PRODUCTION of Low Ash and Sulphur Coal in Illinois as Shown by Float-and-Sink Tests is discussed in Bulletin 258, written by David R. Mitchell and recently issued by the Engineering Experiment Station, University of Illinois, Urbana, Ill. As a result of the investigation, X-ray examination is shown to be a valuable aid in studying the washable characteristics of coal, particularly in illustrating the mode of occurrence and distribution of mineral impurities. From the tests it is apparent that low ash and in some mines a low sulphur coal can be prepared from Illinois mined coal equal to or better than the imported coals.

FLEXIBLE SHAFTS and other related equipment for grinders, buffers and similar equipment are described and illustrated in Catalog 26 recently issued by the N. A. Strand & Co., 5001 No. Lincoln St., Chicago, Ill.

THE AIR PREHEATER CORP., New York, N. Y. (under management of The Superheater Co.), has issued bulletin No. 933. It illustrates various applications of the Ljungström air preheater and should be of interest to public utility and industrial steam power plants and to those interested in industrial heat recovery.

ENGINEERING DATA for set screws and cap screws showing the holding power and recommended size and tightening force is included in an eight-page booklet published by the Allen Manufacturing Co., Hartford, Conn.

HEAT EXCHANGERS, particularly high pressure condensers for cracking coils and vapor lines of refineries are described in a new bulletin by C. H. Leach Co., Inc., 9 Park Place, New York. Title of the bulletin is Leach Fracto Condensers for High Pressure Service.

LARGER RAILROAD Diesels for heavy switchers, main-line passenger and freight service ranging from 1600 to 3500-hp. are described and illustrated in an attractive booklet published by Busch-Sulzer Bros. Diesel Engine Co., St. Louis, Mo.

JOHN WALDRON CORP., New Brunswick, N. J., through their sales agents, Smith & Serrell, Newark, N. J., has issued Bulletin No. 48 dealing with the Waldron Torque Ring Couplings which are of the heavy duty flexible type that have recently been developed.

FRICK Co., Waynesboro, Pa., has published its bulletin No. 164-A under the title of Corrosion Prevention which is a treatise on this subject giving information selected with a view to its service to plant owners and engineers in helping them to increase the useful life of equipment that is subject to corrosion from contact with refrigerating brine.

ROOTS-CONNERSVILLE BLOWER CORP. of Connersville, Ind., has just issued Bulletin 60-B10, descriptive of Cycloidal rotary pumps. These pumps are built on the two-impeller principle, with two and three-lobe impellers, depending upon the type of service to which they are applied.

Power Plant Construction News

Calif., Burbank—Three G Distillery, Ltd., Burbank, care of Arlos R. Sedgley, 910 North Serrano Avenue, Los Angeles, architect, plans installation of electric power equipment in new one-story distilling plant at 3112 West San Fernando Road, Burbank. Entire project will cost over $75,000. Daniel Greenberg is president.

Calif., San Jose—Central California Berry Growers' Association, 510 Battery Street, San Francisco, Calif., plans construction of new cold storage and precooling plant on site near San Jose, estimated to cost close to $30,000, with equipment. Engineering department in charge. George Webb is president.

Colo., Aspen—Roaring Fork Light & Power Co., Aspen, plans construction of new transmission line to Taylor River conservation dam, for power service for construction work. Entire project will cost close to $100,000, with power substation. Company engineering department is in charge.

Ill., Chicago—Campbell Soup Co., Camden, N. J., plans installation of electric power equipment in new five and two-story additions to branch plant at Chicago. Plans now being drawn and work scheduled to begin at early date. Entire program will cost over $750,000.

Iowa, Oelwein—Chicago-Great Western Railroad Co., 122 South Michigan Avenue, Chicago, Ill., plans installation of electric power equipment, electric hoists and other mechanical equipment in connection with a remodeling and expansion program at engine repair shops at Oelwein. Entire project reported to cost over $100,000. Company engineering department in charge.

Ky., Cynthiana—John Pointdexter Distilleries Co. is said to be planning installation of electric power equipment in connection with an expansion and improvement program at distillery. Company is arranging for a stock issue totaling $840,000, a portion of proceeds to be used for purpose noted.

Ky., Lawrenceburg—Old Joe Distilling Co. plans installation of electric power equipment, conveyors, vats and other mechanical equipment for expansion and improvements in distillery. Company is arranging for a stock issue of $405,000, a portion of proceeds to be used for purpose noted.

La., New Orleans—Great Southern Alcohol Co., New Orleans, care of Edwin J. Rodriguez, 143 Sherwood Forest Drive, city, engineer, plans early purchase of power equipment for proposed new local plant, including boilers, pumping machinery and auxiliaries, stills, bottling machinery, conveyors, etc. Entire program reported to cost close to $100,000.

La., Winnfield—Louisiana Products Corporation, Commercial Bank Building, Shreveport, La., E. G. Palmer, vice-president, plans construction of boiler plant at proposed new chemical and lime works near Winnfield, where tract of land is being acquired. Electric and steam power equipment will be installed for plant operations. Entire project will cost over $800,000.

Me., Fryeberg Center—Burnham & Morrill Co., Portland, Me., plans installation of motors and other electric power equipment, tanks, conveyors, etc., in proposed new branch food products canning plant at Fryeberg Center, reported to cost over $60,000, with machinery.

Md., Baltimore—Consolidated Gas, Electric Light & Power Co., Lexington Building, plans new power substation, in connection with power service for electrified lines of Pennsylvania Railroad now under way, for which contract has been secured. It is estimated to cost close to $1,000,000, with equipment. Company engineering department is in charge.

Mass., Chelsea—Board of Trustees, Soldiers' Home, Chelsea,, plans extensions and improvements in power house at institution, with installation of additional equipment. Fund of $90,000 is being arranged through Federal aid. Coolidge, Shepley, Bulfinch & Abbott, 1 Court Street, Boston, Mass., are architects.

Mich., Grand Rapids—Grand Rapids Brewing Co., recently reorganized, G. A. Kusterer, president, plans installation of electric power equipment in connection with new local brewery. Company has taken over former local plant of the H. M. Reynolds Shingle Co., and will remodel and equip. Work is reported to cost over $75,000. Mildner & Eisen, Hammond Building, Detroit, Mich., are architects.

Mich., Houghton—A. Haas Brewing Co. plans installation of power equipment, tanks and other mechanical equipment for an expansion and improvement program at local brewery. Company has arranged for increase in capital from $100,000 to $175,000 to provide fund for work.

Mich., Sodus—Board of Trustees, Sodus Fruit Exchange, Sodus, is considering early rebuilding of cold storage and refrigerating plant, recently destroyed by fire, with loss reported at close to $45,000.

Minn., Cold Spring—Cold Spring Brewing Co., Ferdinand Peters, president, plans installation of electric power equipment, boilers and other mechanical equipment for extensions and improvements in brewing plant. Entire project will cost about $85,000, and work is scheduled to begin early in the spring. L. C. Pinault, Granite Exchange Building, St. Cloud, Minn., architect.

Minn., Minneapolis—Kelley Breweries & Distilleries, Inc., Room 203, 1923 Nicollet Avenue, P. J. Kelley, president, plans installation of boilers and accessories, refrigerating machinery, motors and other electric power equipment in connection with an expansion and improvement program at plant at Fourteenth Avenue, South, and Second Street, three-story and basement, 150x 150 ft. Entire project reported to cost about $300,000, and financing is being arranged in that amount.

Mo., Kansas City—M. K. Goetz Brewing Co., Kansas City, care of George L. Lehle, 111 West Washington Street, Chicago, Ill., architect, recently organized by L. A. Keck, St. Joseph, Mo., and associates, plans installation of electric power equipment in proposed new brewing plant at Indiana Avenue and Seventeenth Street, Kansas City, where site has recently been acquired. Architect noted is in charge. Entire project will cost over $150,000.

Mo., Moberly—City Council has engaged Russell & Axon, 4903 Delmar Boulevard, St. Louis, Mo., consulting engineers, to prepare plans for a proposed municipal electric light and power plant. A bond issue of $700,000 is being arranged for project, financing to be secured through Federal aid. H. W. Thomas, Jr., is city engineer.

N. J., Paulsboro—Sandura Co., Inc., Finance Building, Philadelphia, Pa., plans installation of motors and other electric power equipment in connection with proposed rebuilding of portion of linoleum plant at Paulsboro, recently destroyed by fire, with loss estimated at over $500,000, with machinery. Robert Stewart is superintendent at plant.

N. Y., Lockport—Common Council has tentative plans under way for a municipal hydroelectric power plant for street-lighting and other municipal service, with initial capacity of about 5,000 hp. It is proposed to use water from the Niagara River and application for permission will soon be made. Project is reported to cost over $150,000. L. A. Harding, Prudential Building, Buffalo, N. Y., consulting engineer.

Ohio, Cleveland—Department of Public Utilities, City Hall, William J. Rogers, director, has preliminary plans for extensions and improvements in municipal electric light and power plant at East Fifty-third Street and lake front, including installation of new equipment. Entire project reported to cost over $200,000. Work will begin early in spring.

Ohio, Cleveland—Winton Engine Co., 2160 West 106th Street, manufacturer of automobile engines, plans installations of motors, conveyors and other electric power equipment in new one-story plant addition, 65x200 ft., for which building permit has been issued. Entire project will cost about $70,000. A. E. Rowe, 1291 East 133rd Street, is engineer.

Ont., Aldershot—R. L. Scott and Associates, care of E. H. Darling, 36 James Street, South, Hamilton, Ont., engineer, have plans under way for new one-story and basement cold storage and precooling plant on local site, estimated to cost about $65,000, with equipment. It is proposed to begin work at early date.

S. C., Anderson—Appleton Co. plans installation of motors and other electric power equipment, conveyors, etc., in new one-story addition to cotton mill, 110 x 910 ft., to be used as a bleachery. Estimated cost about $150,000, with machinery. J. E. Sirrine & Co., Greenville, S. C., is architect and engineer.

Texas, Texas City—Sun Oil Co., 1608 Walnut Street, Philadelphia, Pa., plans installation of boilers, tanks, pumping machinery, electric power equipment, pipe lines, etc., in new refining plant at Texas City, where 250 acres of land is being secured. Entire program is reported to cost over $500,000. Company engineering department is in charge.

Va., Ampthill—duPont Rayon Co., Ampthill, near Richmond, Va., plans installation of electric power equipment, conveyors and other mechanical equipment, in connection with new units at local rayon mill. Entire project will cost over $3,000,000. Willis Shackelford is plant manager. Headquarters of company are at 350 Fifth Avenue, New York.